'*Cosmodrome*': an experimental design to study movements and behavior of the banana weevil, *Cosmopolites sordidus*, using RFID

Dominique Carval

Philippe Tixier & Pierre-François Duyck

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Cosmopolites sordidus

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Cosmopolites sordidus

- Walking insect

(Cuillé 1950; Roth & Willis 1963; Gold *et al.* 2001)

Cosmopolites sordidus

- Walking insect
-  Major pest of banana crops

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(Cuillé 1950; Roth & Willis 1963; Gold *et al.* 2001)

Cosmopolites sordidus

- Walking insect
- Major pest of banana crops
-  Nocturnally active

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(Cuillé 1950; Roth & Willis 1963; Gold *et al.* 2001)

Cosmopolites sordidus

- Walking insect
- Major pest of banana crops
- Nocturnally active
-  Cryptic

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(Cuillé 1950; Roth & Willis 1963; Gold *et al.* 2001)

Cosmopolites sordidus

- Walking insect
- Major pest of banana crops
- Nocturnally active
- Cryptic
-  Hygrotropic

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(Cuillé 1950; Roth & Willis 1963; Gold *et al.* 2001)

Cosmopolites sordidus

- Walking insect
- Major pest of banana crops
- Nocturnally active
- Cryptic
- Hygrotropic
-  Sexual dimorphism

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(Cuillé 1950; Roth & Willis 1963; Gold *et al.* 2001)

Cosmopolites sordidus

- Sexual dimorphism

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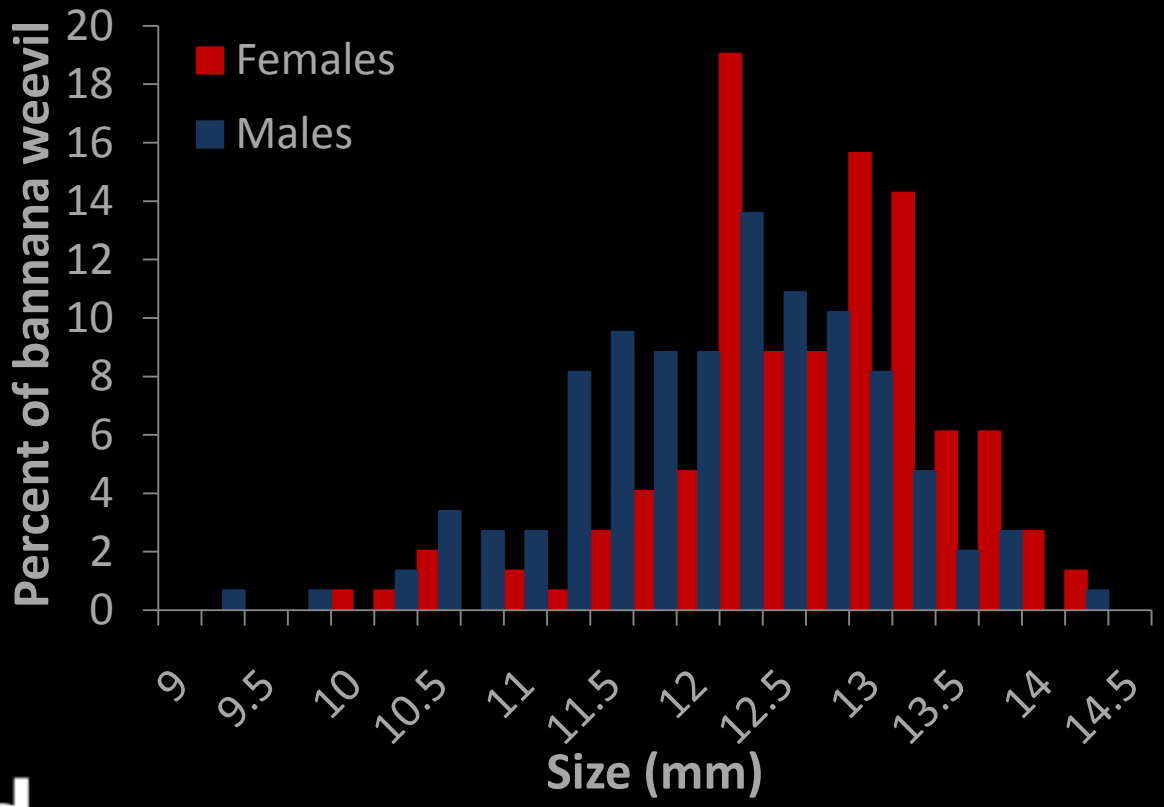
(Gold *et al.* 2001)

Cosmopolites sordidus

Sexual dimorphism

females are larger than males

(p-value < 0.0001)



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(Gold *et al.* 2001)

Cosmopolites sordidus

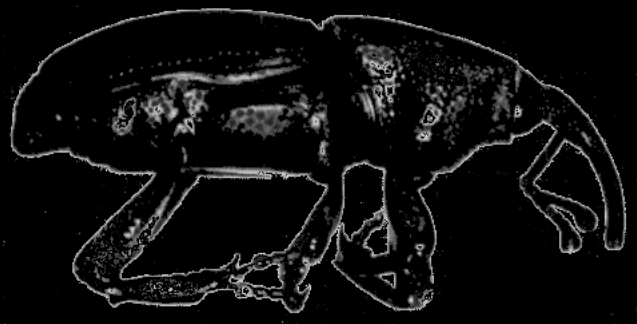
- Sexual dimorphism

cirad

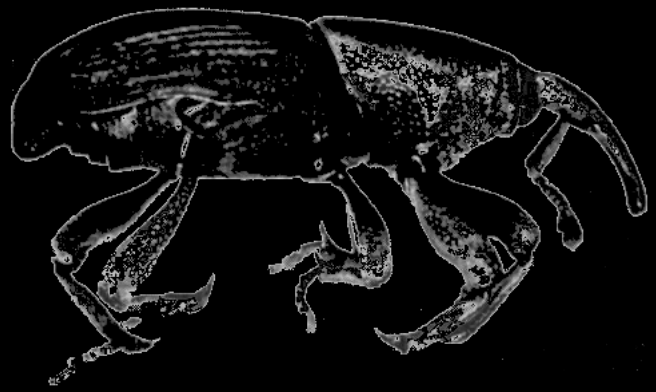
(Roth & Willis 1963; Gold *et al.* 2001)

Cosmopolites sordidus

- Sexual dimorphism



Last abdominal sternite ♀



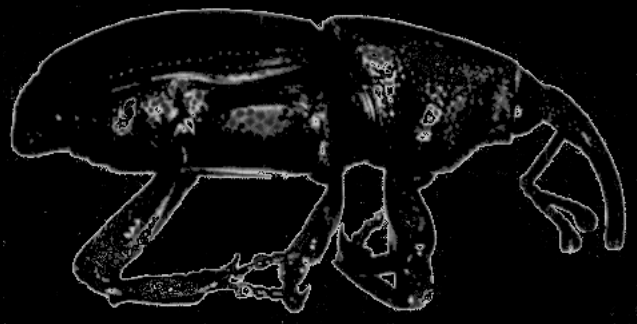
Last abdominal sternite ♂

cirad

(Roth & Willis 1963; Gold *et al.* 2001)

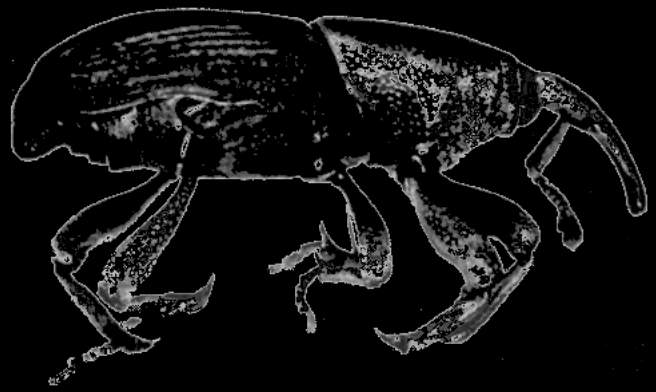
Cosmopolites sordidus

- Sexual dimorphism



Last abdominal sternite ♀

Rostrum ♀



Last abdominal sternite ♂

Rostrum ♂

cirad

(Roth & Willis 1963; Gold *et al.* 2001)

Cosmopolites sordidus

- Walking insecte
- Major pest of banana crops
- Nocturnally active
- Cryptic
- Hygrotropic
- Sexual dimorphism
-  Dispersion & movements

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(Cuillé 1950; Roth & Willis 1963; Gold *et al.* 2001)

Cosmopolites sordidus

- Dispersion & movements

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Cosmopolites sordidus

Dispersion & movements

Slow and limited[(1)]

- e.g. 0.5 meter per day
- e.g. maximal distance of 9 meters per day

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([(1)] Vinatier *et al.* 2009; [(2)] Vinatier *et al.* 2011; [(3)] Roth & Willis 1963)

Cosmopolites sordidus

Dispersion & movements

Slow and limited[(1)]

- e.g. 0.5 meter per day
- e.g. maximal distance of 9 meters per day

Habitat dependant[(2)]

- e.g. bare soil → probability of departure is high
- e.g. banana plant → probability to stay is high

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([(1)] Vinatier *et al.* 2009; [(2)] Vinatier *et al.* 2011; [(3)] Roth & Willis 1963)

Cosmopolites sordidus

Dispersion & movements

Slow and limited[(1)]

- e.g. 0.5 meter per day
- e.g. maximal distance of 9 meters per day

Habitat dependant[(2)]

- e.g. bare soil → probability of departure is high
- e.g. banana plant → probability to stay is high

Humidity[(3)]

- e.g. high humidity → sedentarity
- e.g. low humidity → unsettlement

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([(1)] Vinatier *et al.* 2009; [(2)] Vinatier *et al.* 2011; [(3)] Roth & Willis 1963)

Cosmopolites sordidus

- Dispersion & movements

Epidemiological front = colonization of banana plots

- Spatial organization, habitat dependence
- Interaction between individuals
  - Study of the behavioral response at local scale
    - Movements between neighbors banana plants
    - Local density of individuals by banana plant
    - Local sex ratio
    - Local mating
    - Local egg laying

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([1] Vinatier *et al.* 2009; [2] Vinatier *et al.* 2011; [3] Roth & Willis 1963)

Cosmopolites sordidus

- Walking insect
- Major pest of banana crops
- Nocturnally active
- Cryptic
- Hygrotropic
- Sexual dimorphism
- Dispersion & movements
-  Density effects

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(Cuillé 1950; Roth & Willis 1963; Gold *et al.* 2001)

Cosmopolites sordidus

- Density effects

(Koppenhöfer 1993; Abera *et* al. 1999; Gold *et al.* 2002a)

Cosmopolites sordidus

Density effects

Oviposition rate is higher at low density

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(Koppenhöfer 1993; Abera *et* al. 1999; Gold *et al.* 2002a)

Cosmopolites sordidus

Density effects

Oviposition rate is higher at low density

Larval survivorship is higher at low density

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(Koppenhöfer 1993; Abera *et* al. 1999; Gold *et al.* 2002a)

Cosmopolites sordidus

Density effects

Oviposition rate is higher at low density

Larval survivorship is higher at low density

Larval developpment is quicker at high density

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(Koppenhöfer 1993; Abera *et* al. 1999; Gold *et al.* 2002a)

Cosmopolites sordidus

Does the local density of banana weevil affect the behavior of individuals ?

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Experimental design

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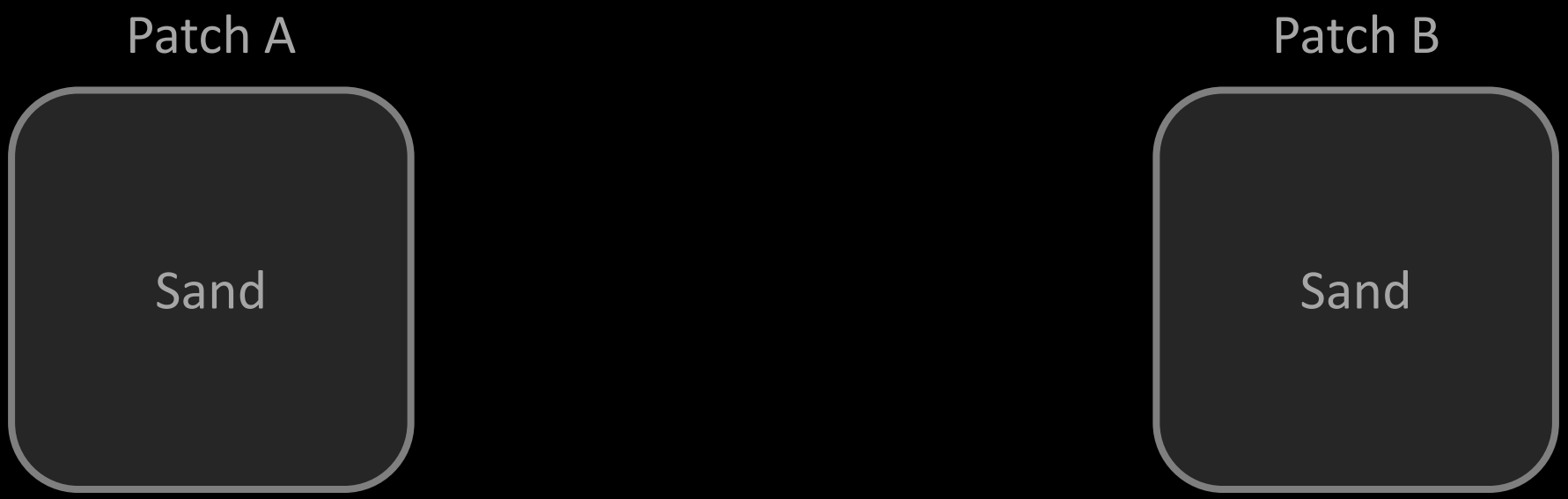
Experimental design



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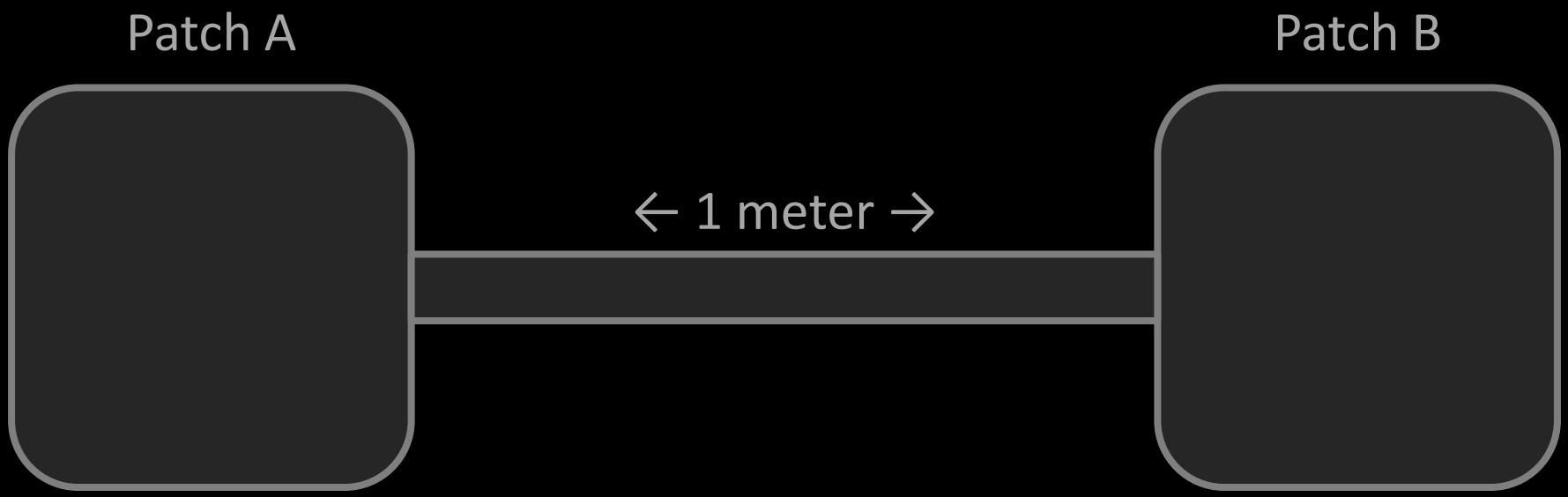

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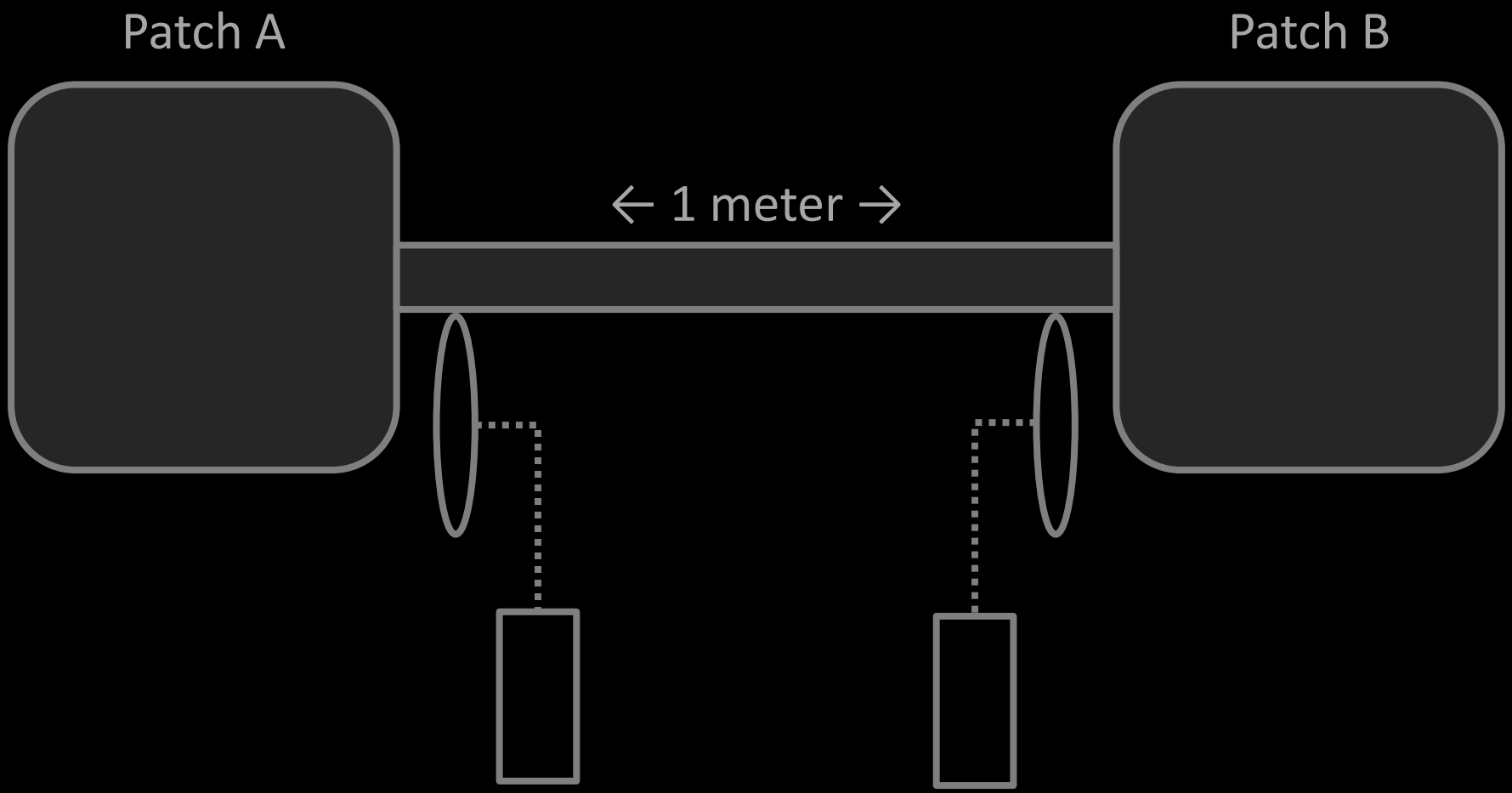

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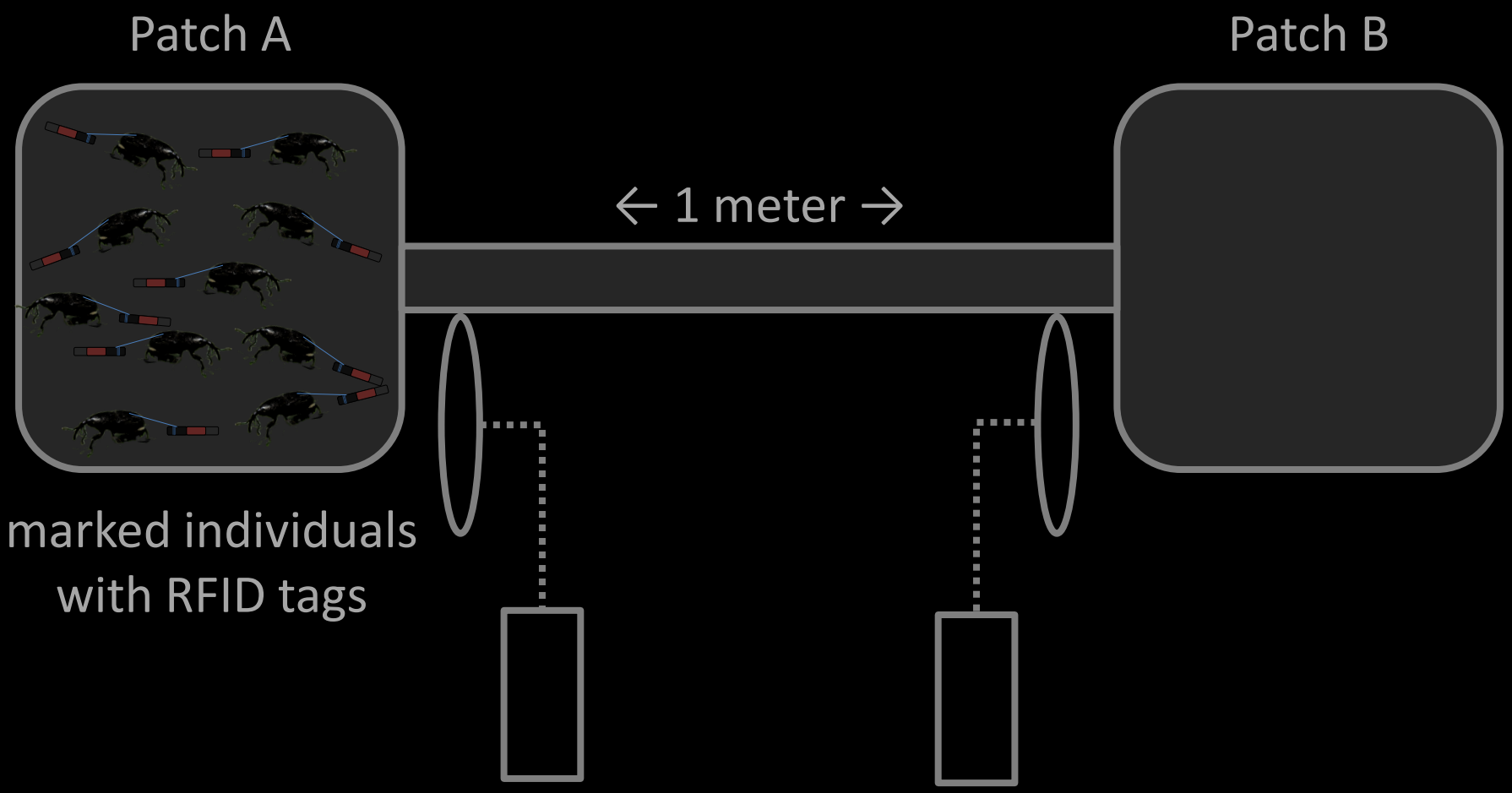

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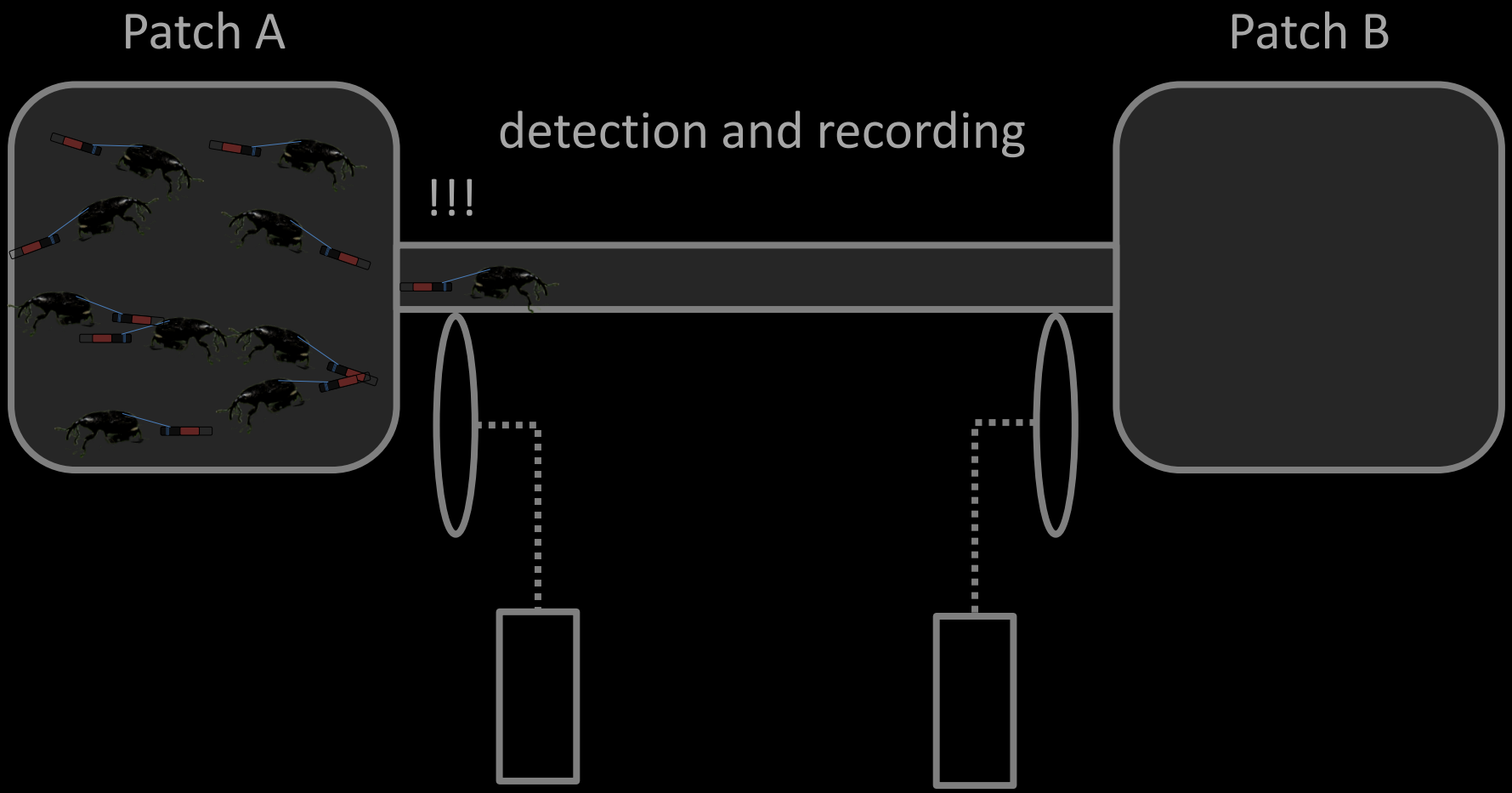

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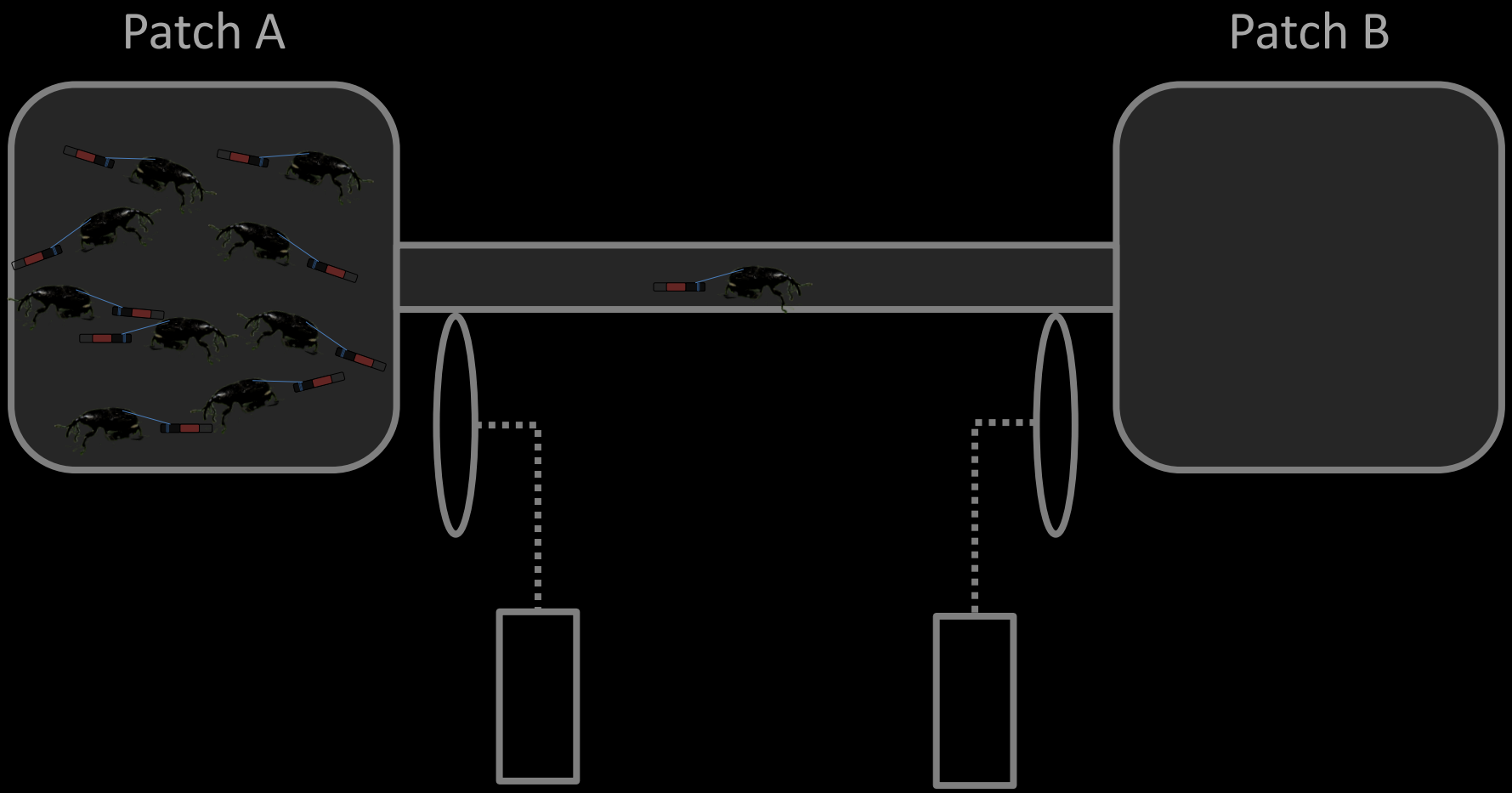

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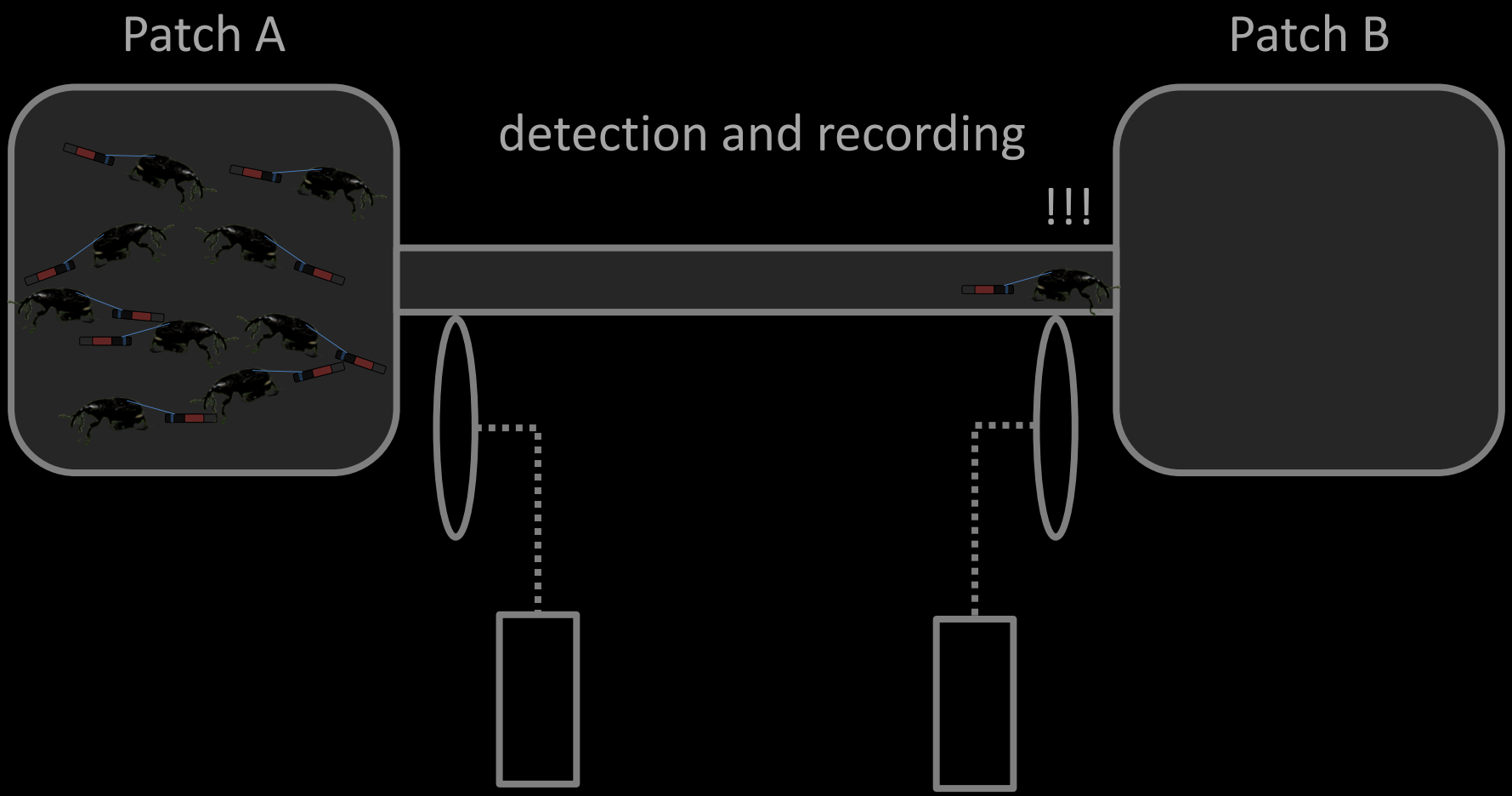

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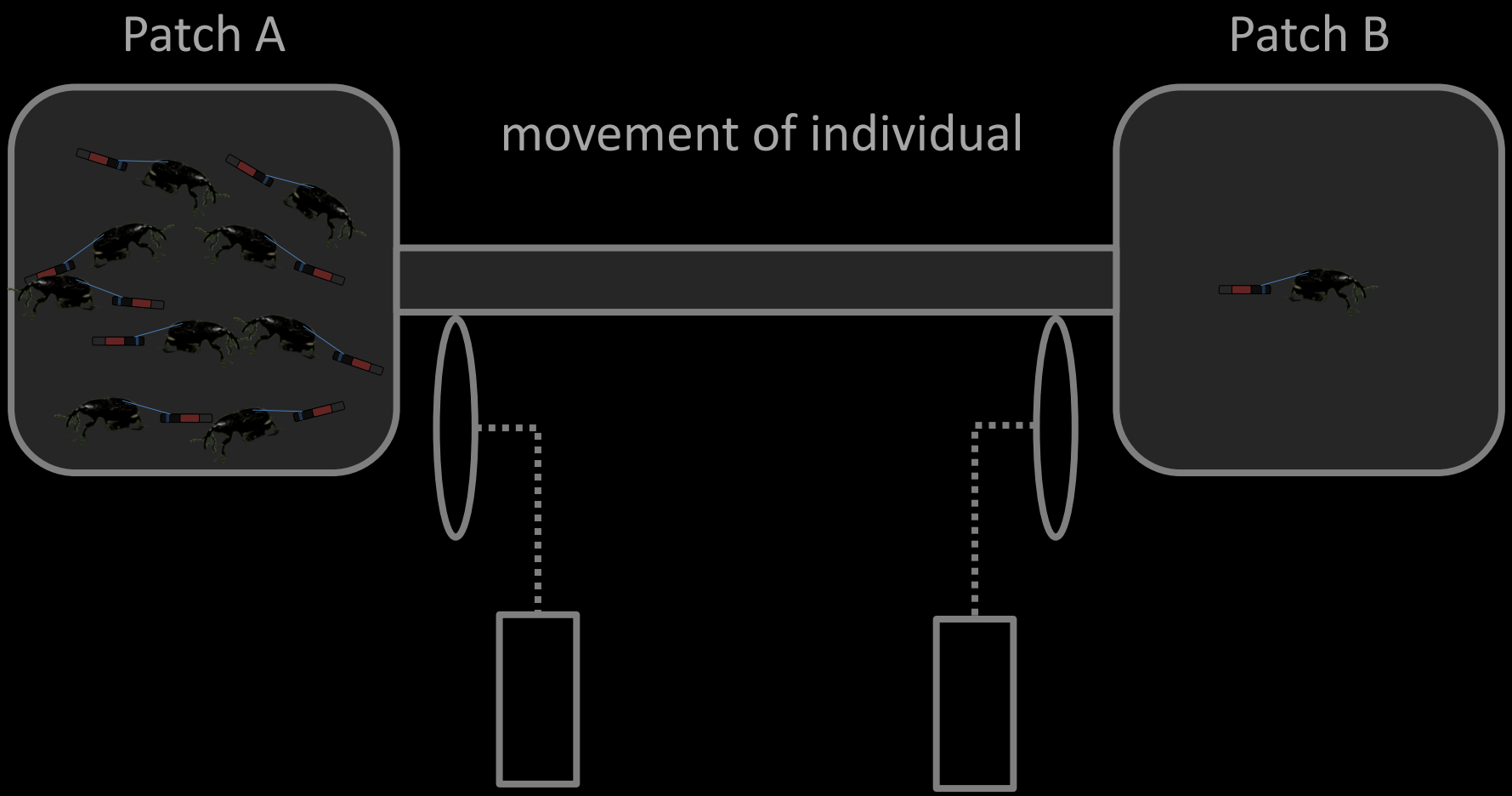

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Experimental design

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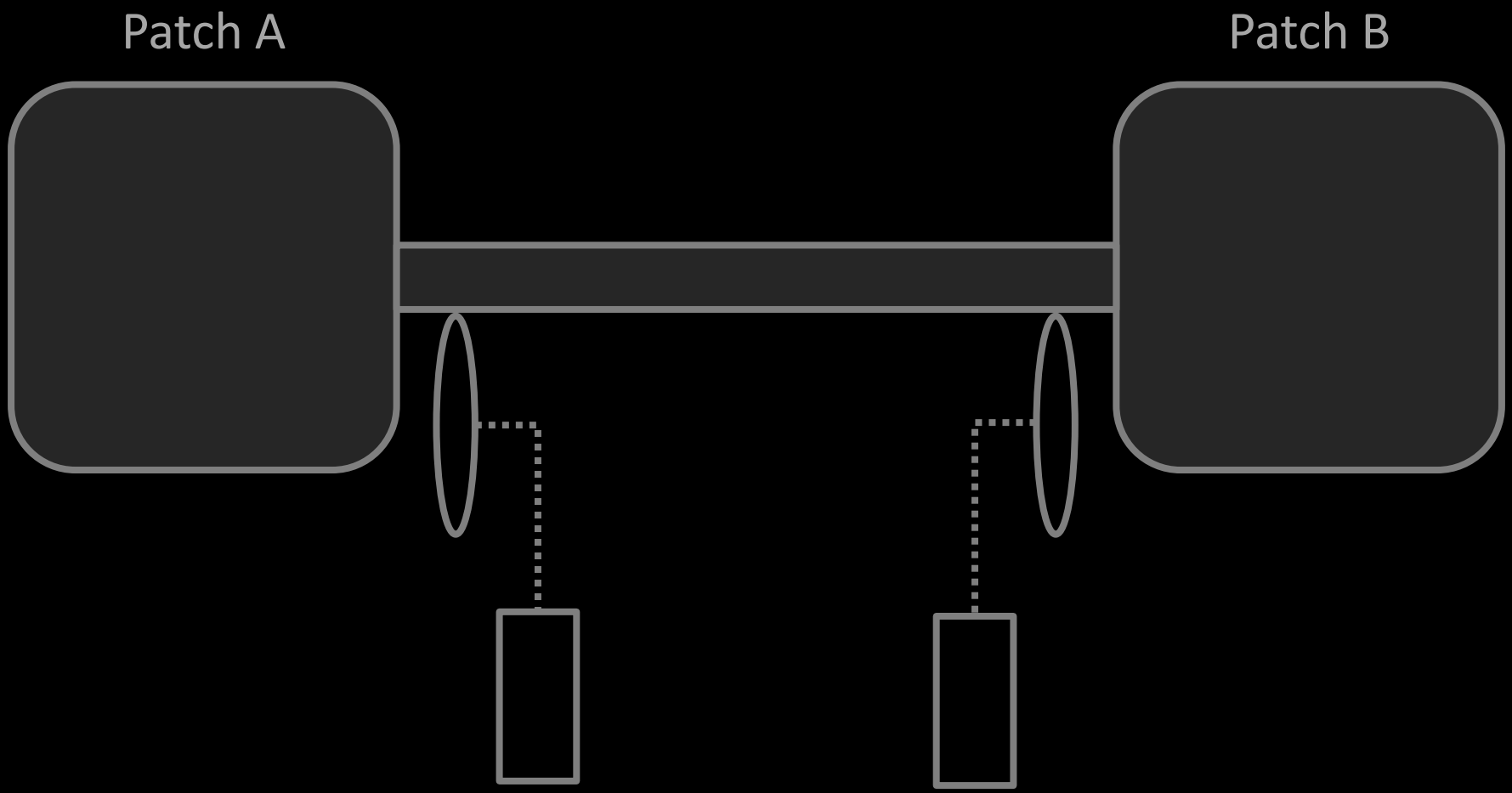
Experimental design



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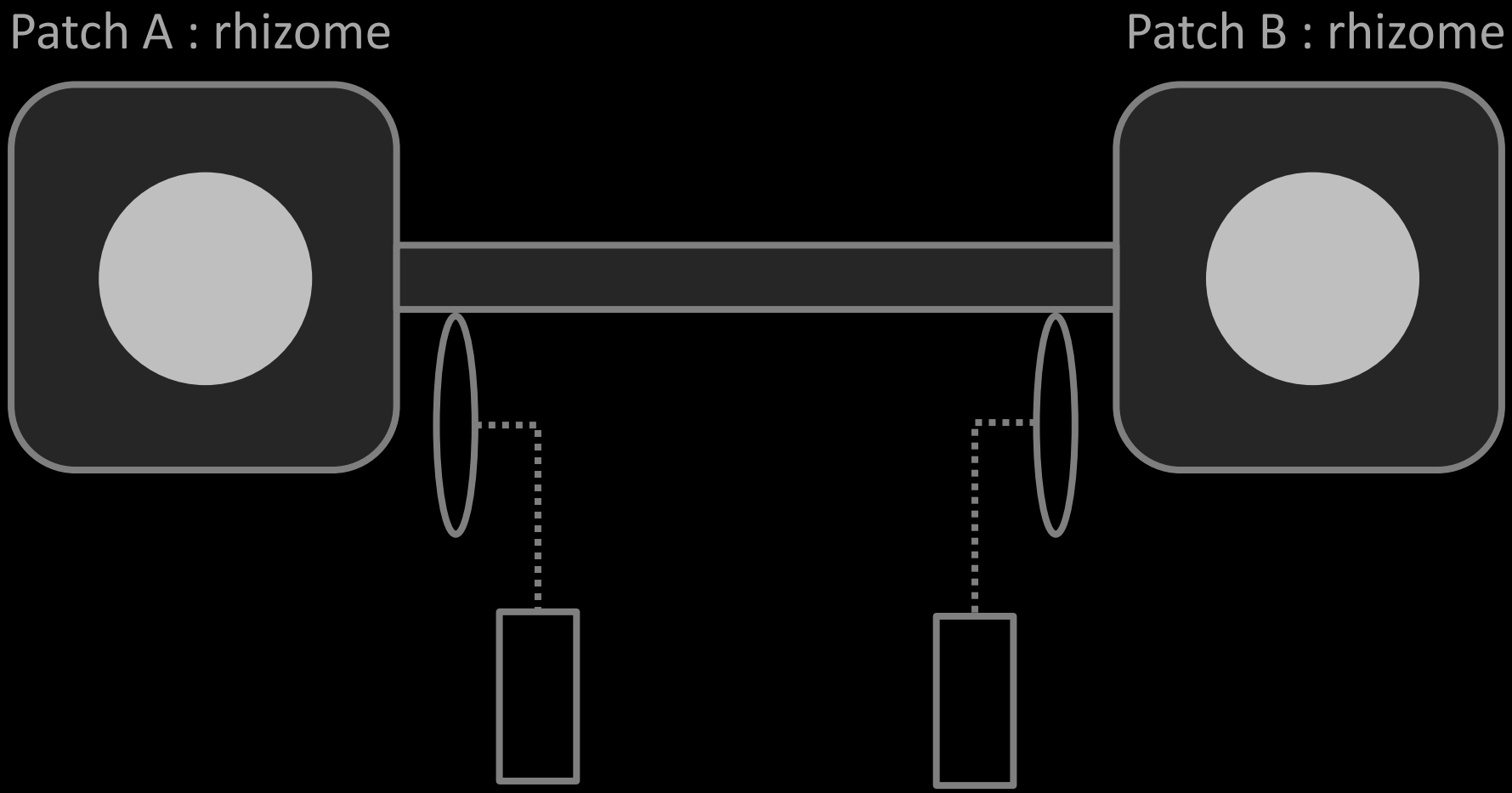

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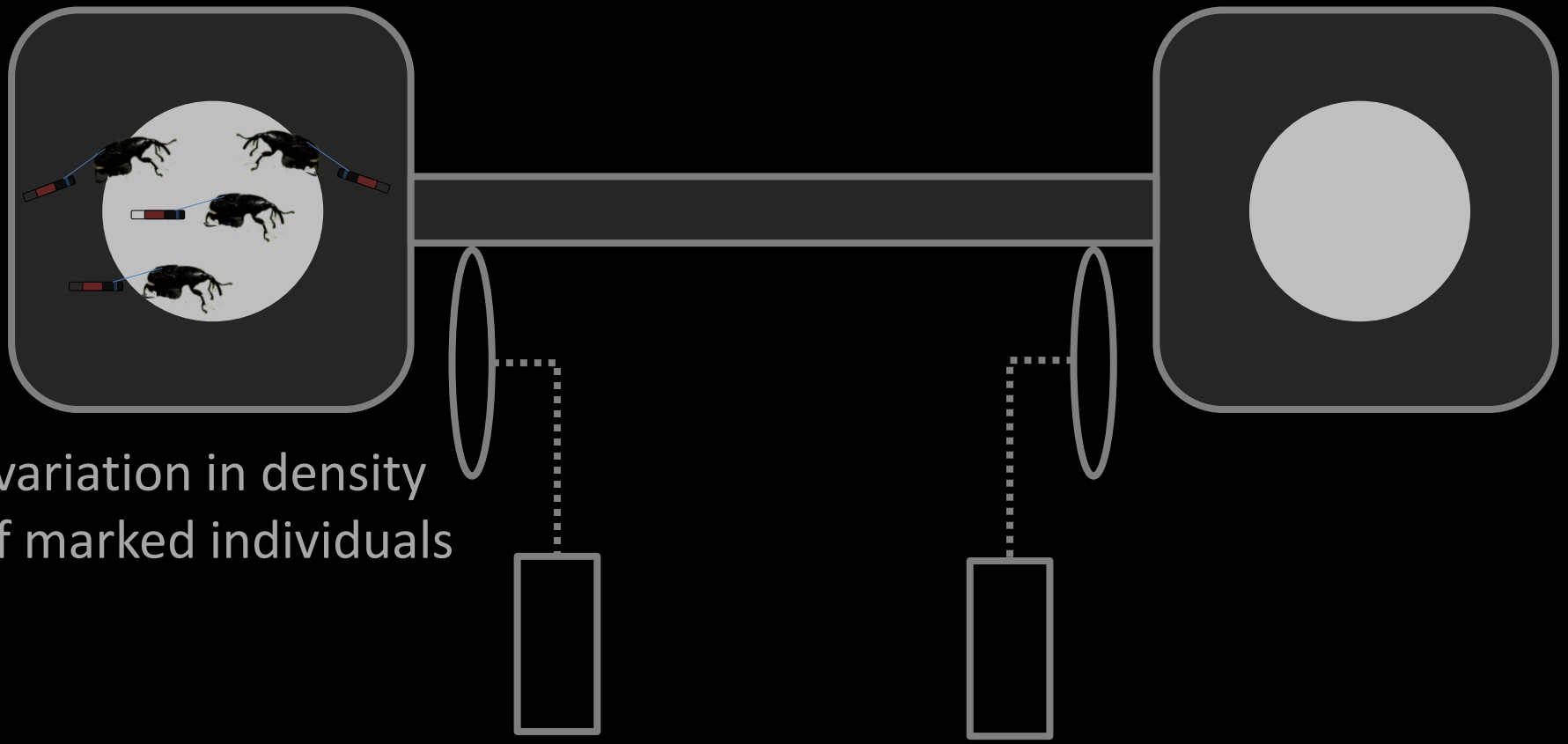

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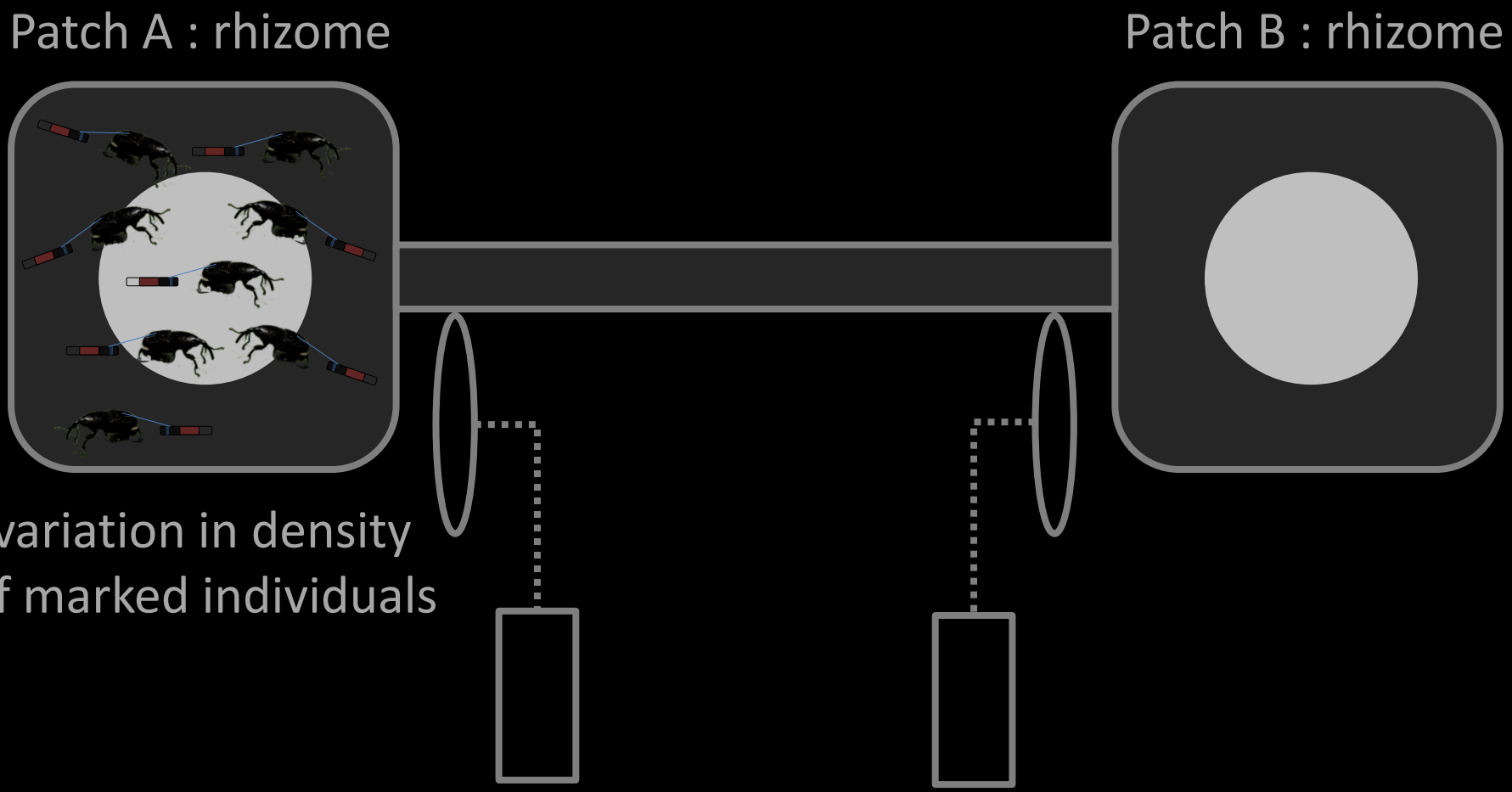

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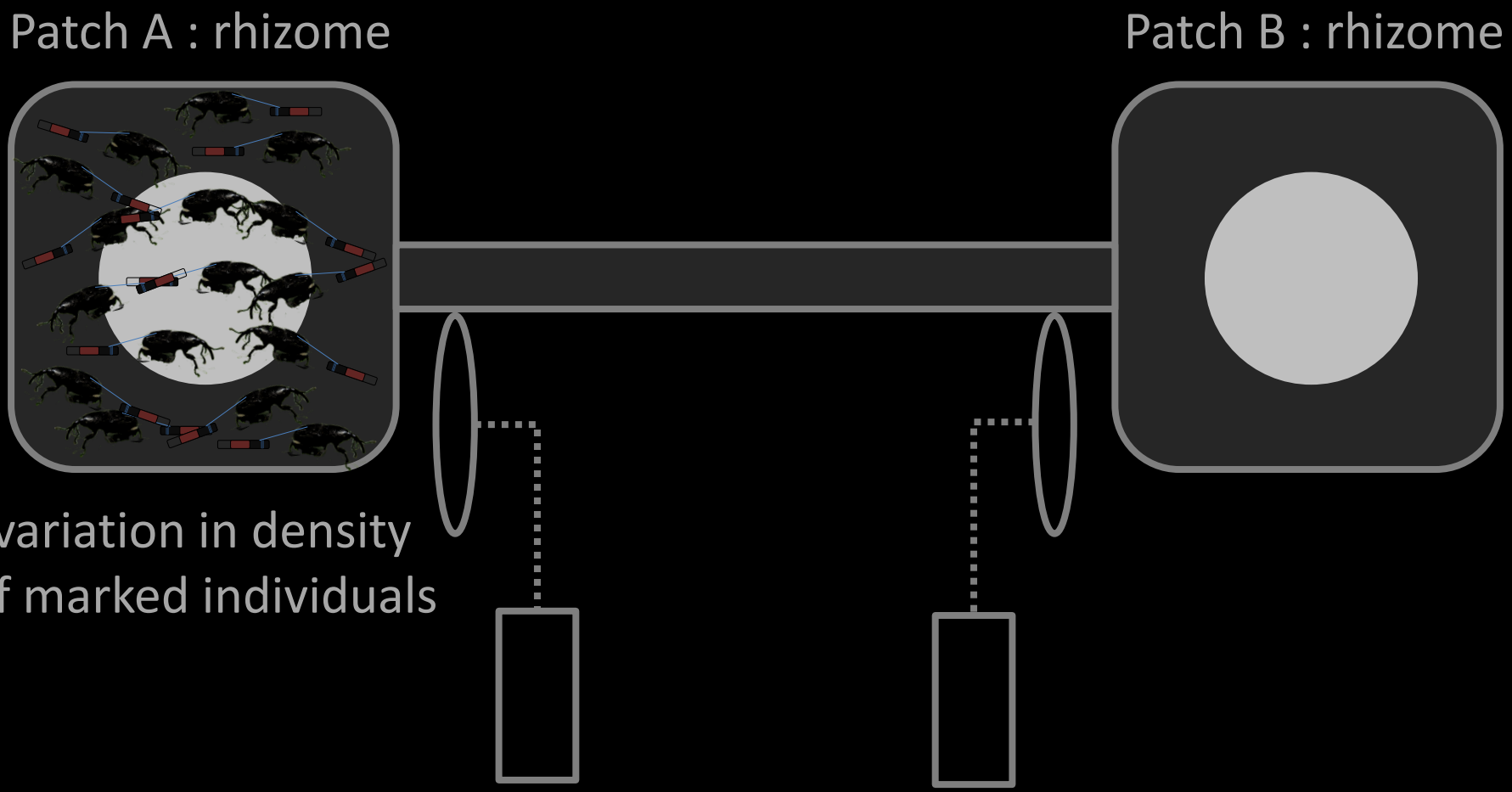

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Results

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Results

Proportion of movers

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Results

Proportion of movers

Individual mean number of movements

cirad

Results

Generalized linear mixed models (GLMMs)

Proportion of movers

Mean number of moves

cirad

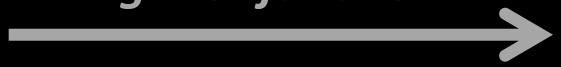
(Bolker *et al.* 2009)

Results

Generalized linear mixed models (GLMMs)

Proportion of movers

glmer function



lme4 - R.2.13.0

Mean number of moves

cirad

(Bolker *et al.* 2009)

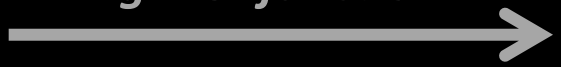
Results

Generalized linear mixed models (GLMMs)

Proportion of movers

Sex

glmer function



lme4 - R.2.13.0

Mean number of moves

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(Bolker *et al.* 2009)

Results

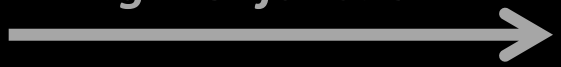
Generalized linear mixed models (GLMMs)

Proportion of movers

Sex

Density (d)

glmer function



lme4 - R.2.13.0

Mean number of moves

cirad

(Bolker *et al.* 2009)

Results

Generalized linear mixed models (GLMMs)

Proportion of movers

Mean number of moves

glmer function

lme4 - R.2.13.0

Sex

Density (d)

Error

Poisson

Binomial

cirad

(Bolker *et al.* 2009)

Results

Generalized linear mixed models (GLMMs)

Proportion of movers

Mean number of moves

glmer function

lme4 - R.2.13.0

Sex

Density (d)

Error
Poisson
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Random effects
Experiment
Individual

cirad

(Bolker *et al.* 2009)

Results

- Proportion of movers

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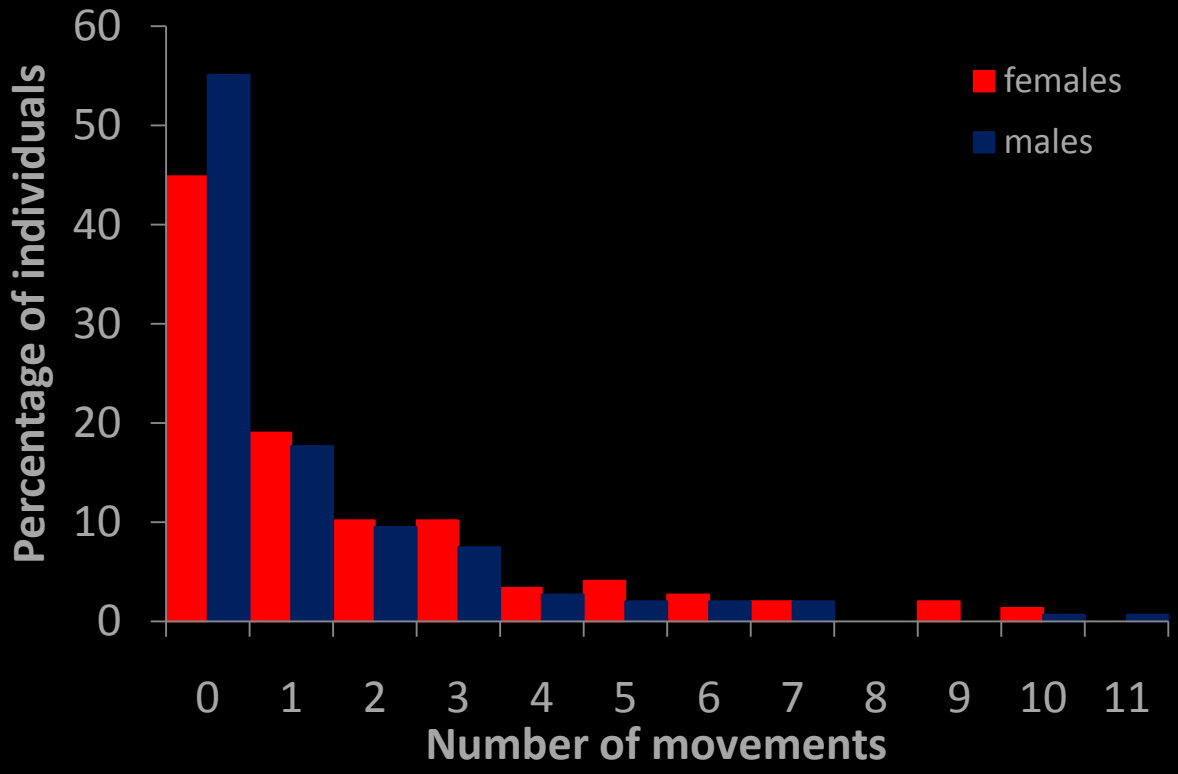
Results

Proportion of movers



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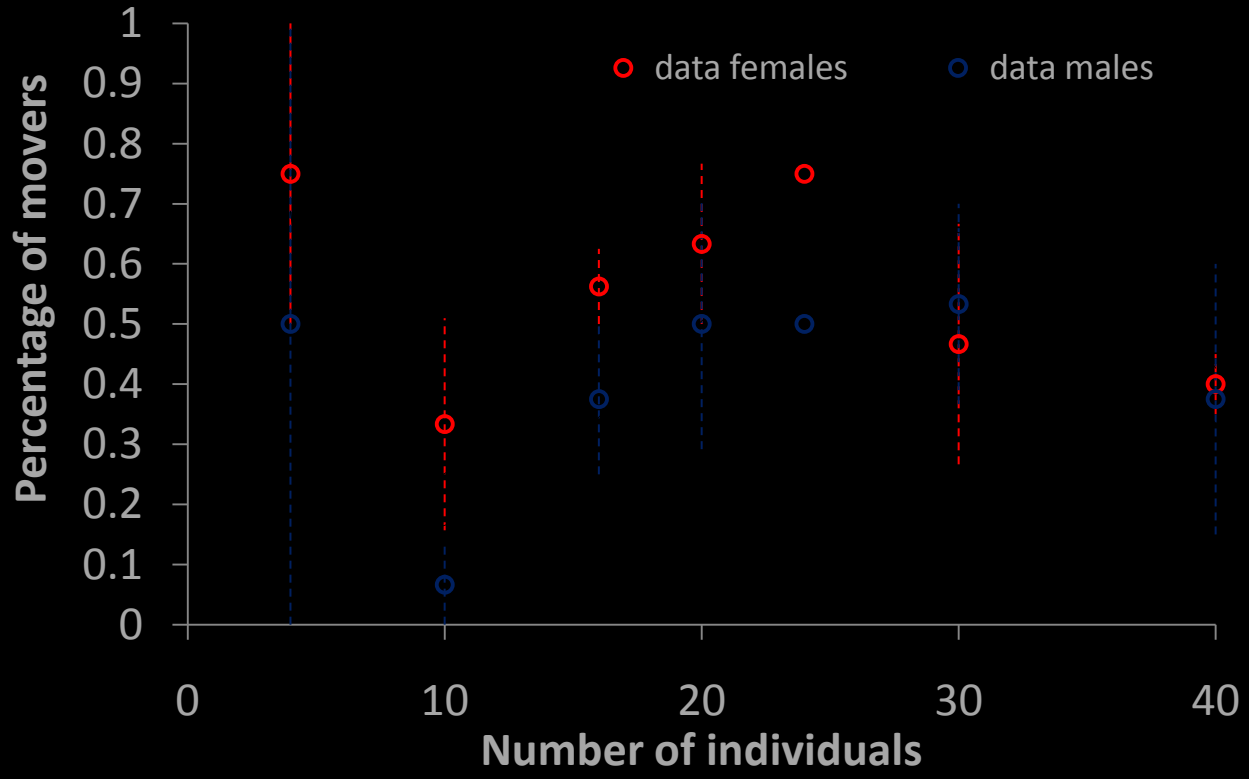
Results

Proportion of movers



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Results

Proportion of movers

Model	df	AIC	Δ AIC	Log-Likelihood	P-value
sex + d + d^2 + 1/d	7	388.8		-187.38	
sex * d + d^2 + 1/d	8	387.6	1.2	-185.83	0.08
sex * d + d^2	6	400.5	11.7	-194.25	< 0.001
sex * d + 1/d	6	413.3	24.5	-200.66	< 0.0001
sex * d	5	411.6	22.8	-199.80	< 0.0001
sex	4	410.1	21.3	-201.05	< 0.0001
Null	3	411.0	21.2	-202.52	< 0.0001

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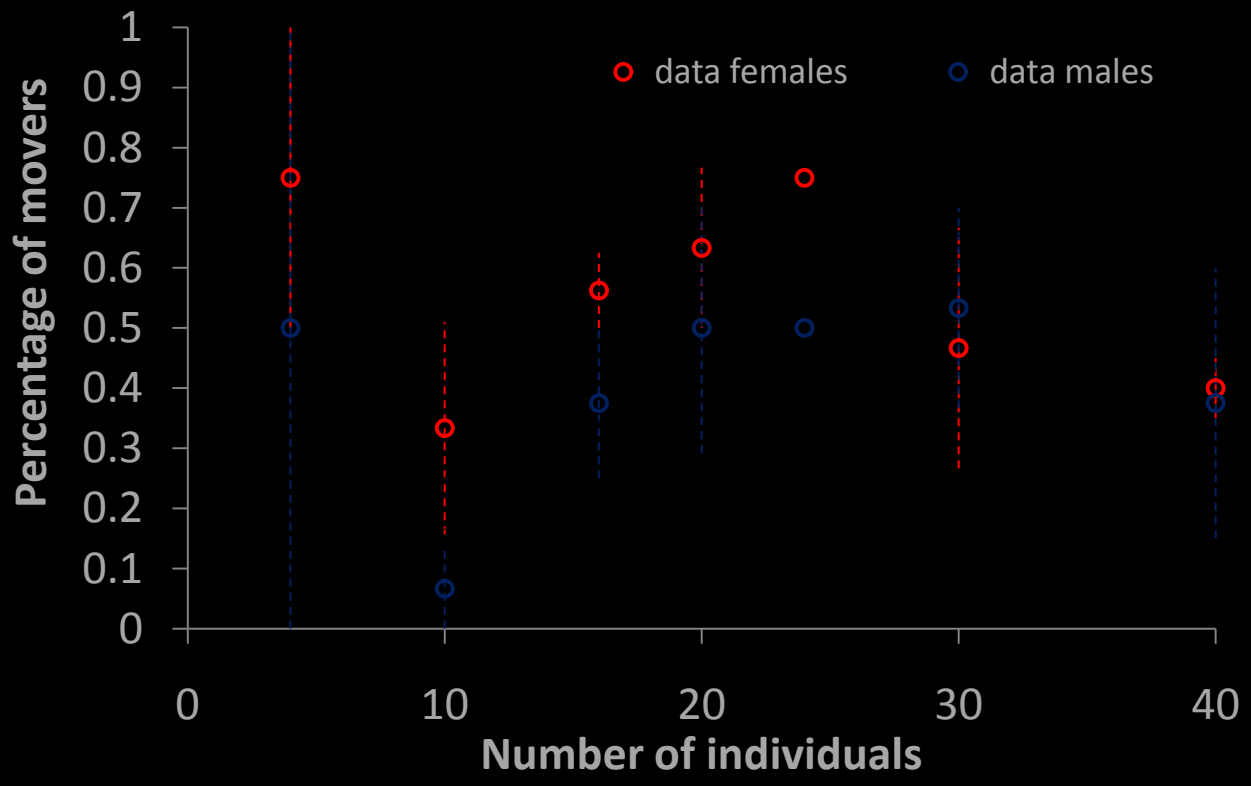
Results

Proportion of movers

prediction of the model : sex and density effects



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Proportion of movers

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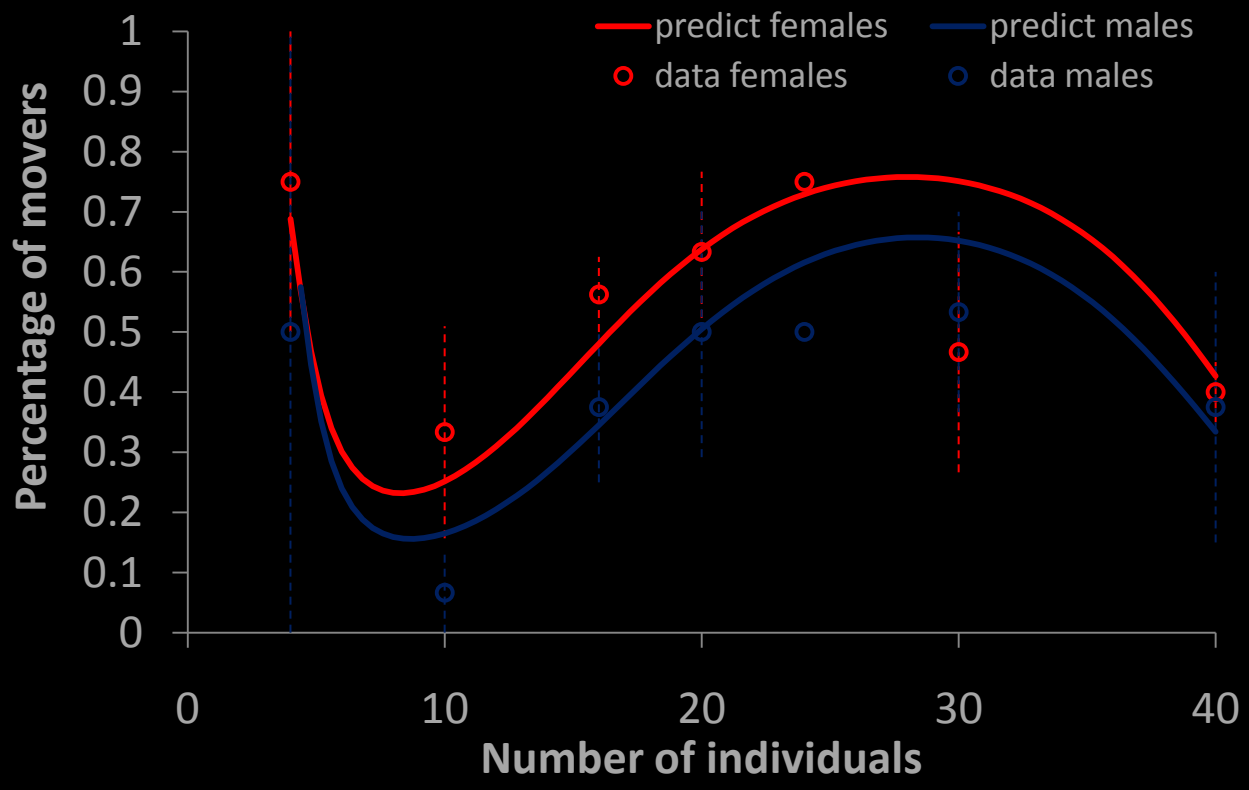

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Results

- Proportion of movers

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Results

Proportion of movers

More individuals move at very low and intermediate densities

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Results

Proportion of movers

More individuals move at very low and intermediate densities

Percentage of individuals that moves is higher for ♀ than ♂

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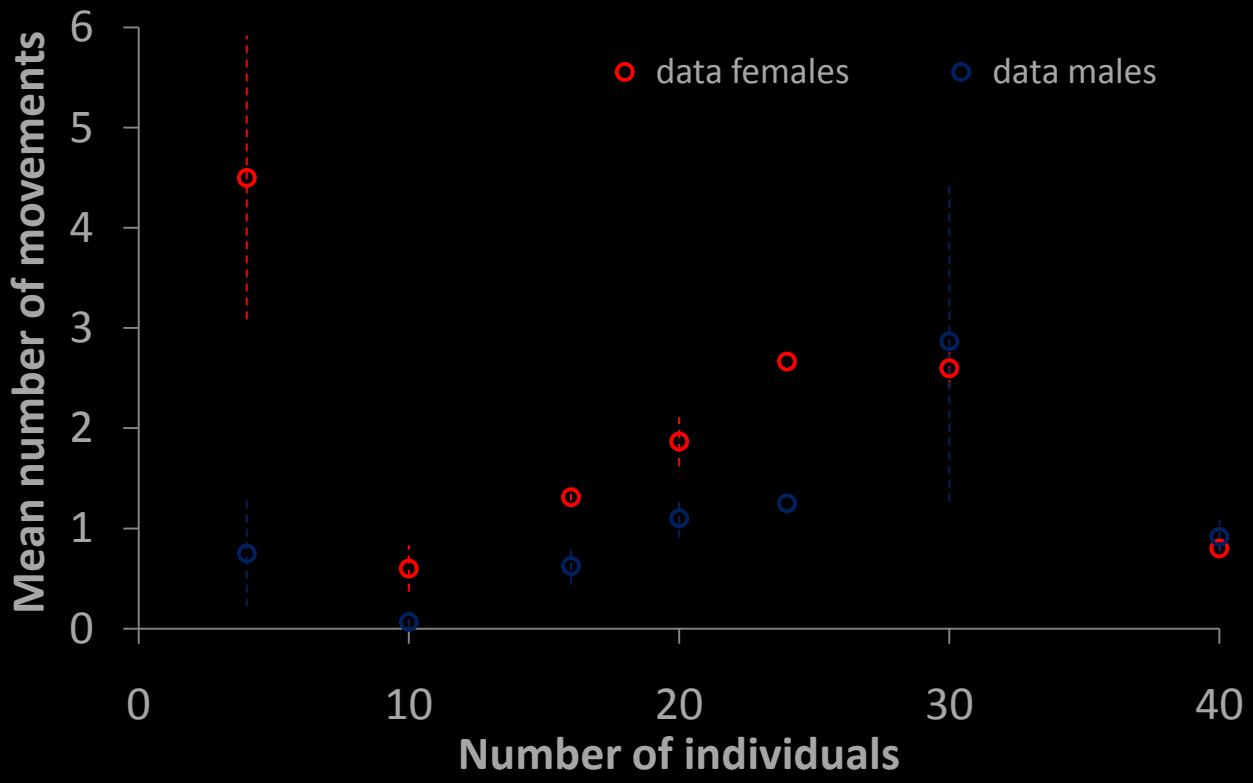
Results

Individual mean number of movements



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Results

Individual mean number of movements

Model	df	AIC	Δ AIC	Log-Likelihood	P-value
sex * d + d^2 + 1/d	8	520.6		-252.28	
sex + d + d^2 + 1/d	7	524.7	4.1	-268.23	< 0.05
sex * d + d^2	7	550.5	29.9	-268.23	< 0.0001
sex * d + 1/d	7	568.7	48.1	-277.35	< 0.0001
sex * d	6	566.9	46.3	-277.47	< 0.0001
sex	4	566.8	46.2	-279.42	< 0.0001
Null	3	568.5	47.9.6	-281.23	< 0.0001

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Results

Individual mean number of movements

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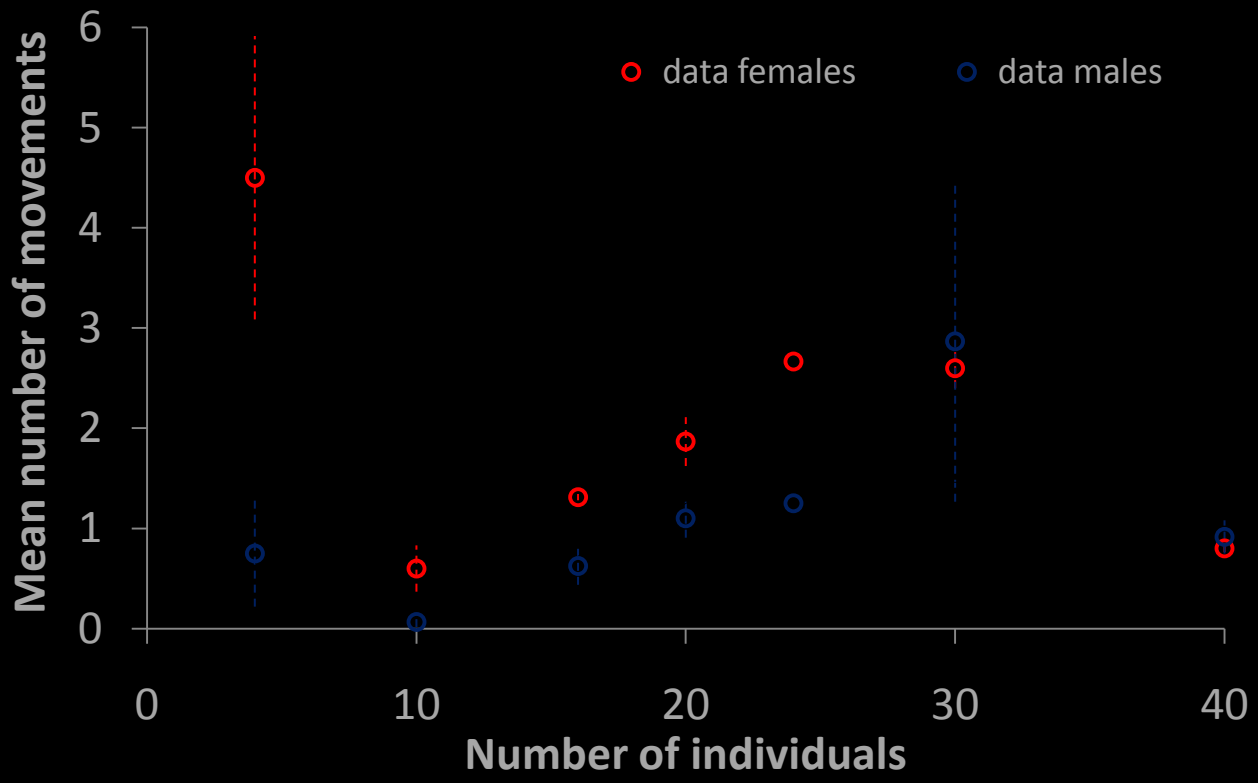
Results

Individual mean number of movements

prediction of the model : sex and density effects



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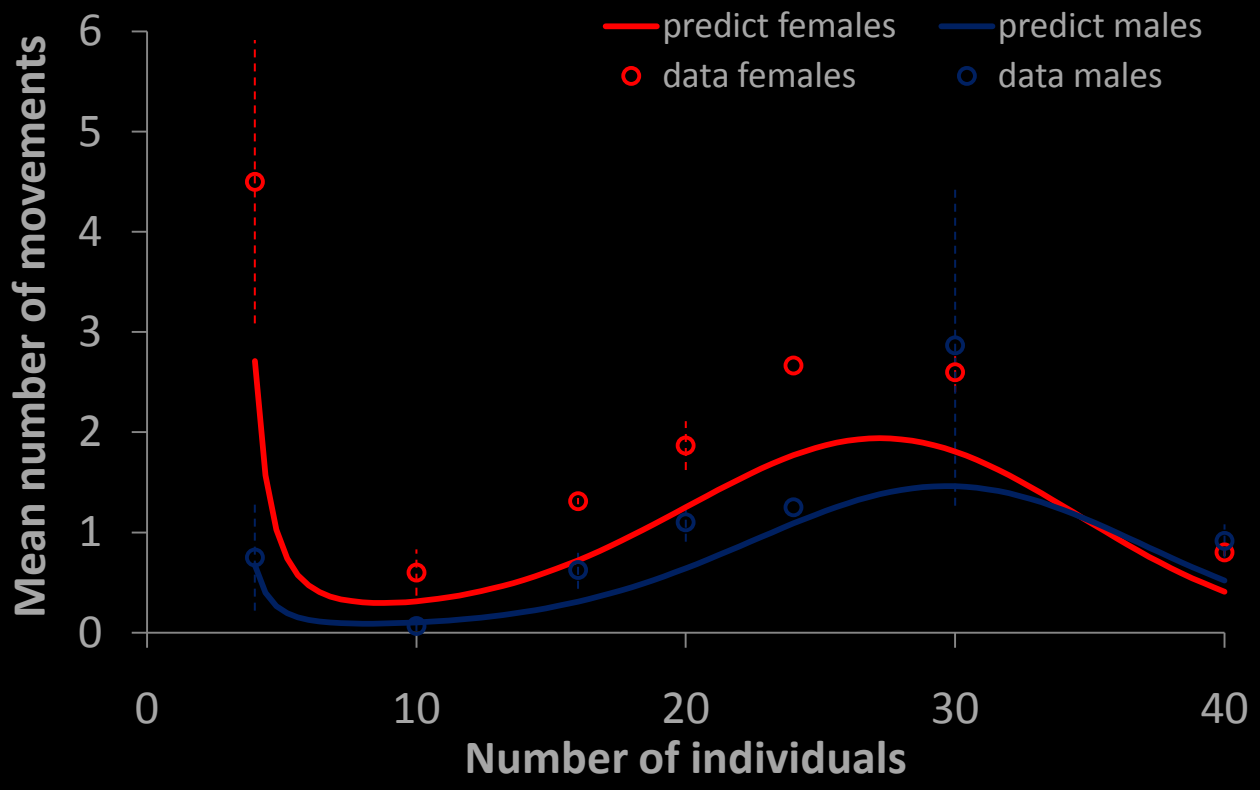
Results

- Individual mean number of movements

prediction of the model : sex and density effects



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Results

Individual mean number of movements

Individuals move more at very low and intermediate densities

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Results

Individual mean number of movements

Individuals move more at very low and intermediate densities

♀ ***move more than*** ♂

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Discussion & Perspectives

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Discussion & Perspectives

How to explain the behavior of* C. sordidus *in response to variation in local density of patch?

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Discussion & Perspectives

How to explain the behavior of C. sordidus *in response to variation in local density of patch?*

Hypothesis : two effects of the local density

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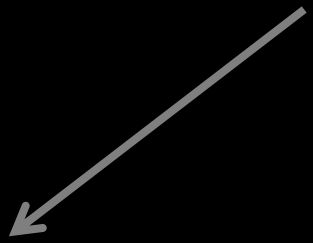
Discussion & Perspectives

How to explain the behavior of* C. sordidus *in response to variation in local density of patch?

Hypothesis : two effects of the local density



Mating

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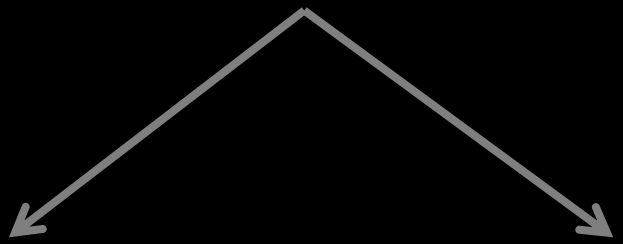
Discussion & Perspectives

How to explain the behavior of* C. sordidus *in response to variation in local density of patch?

Hypothesis : two effects of the local density



Mating ***Resources***

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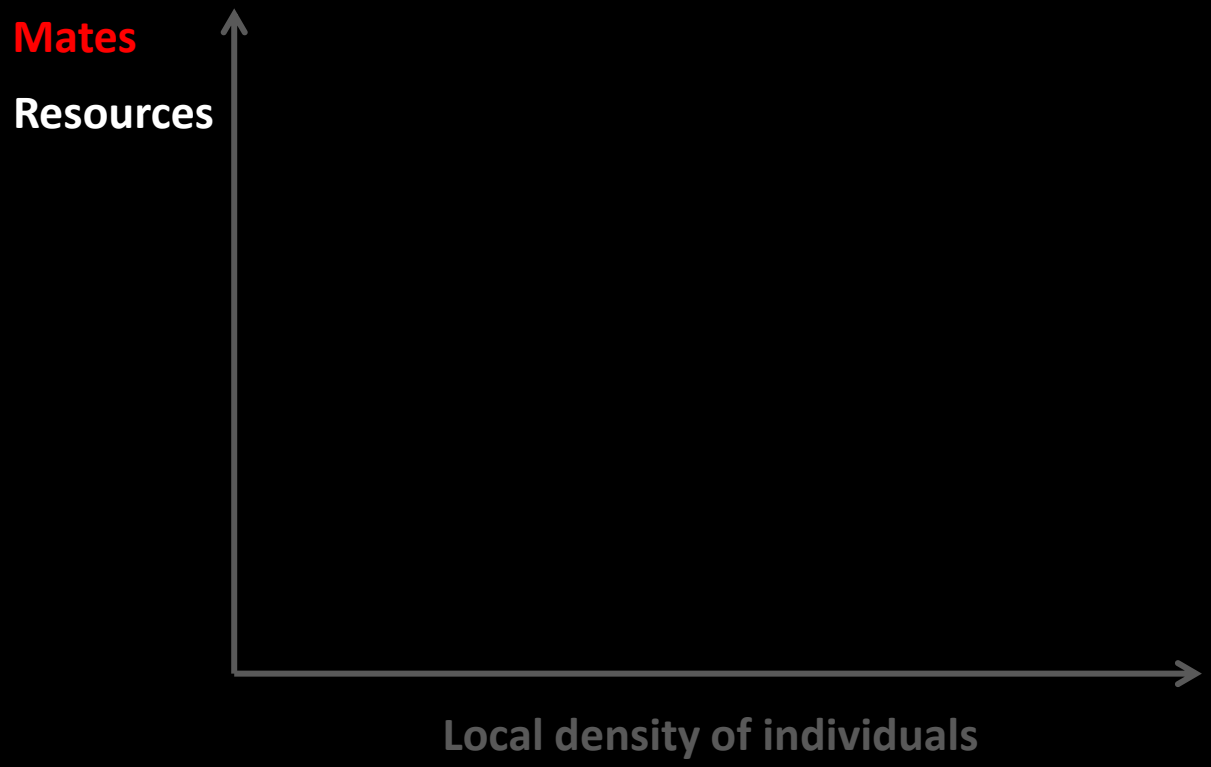
Discussion & Perspectives



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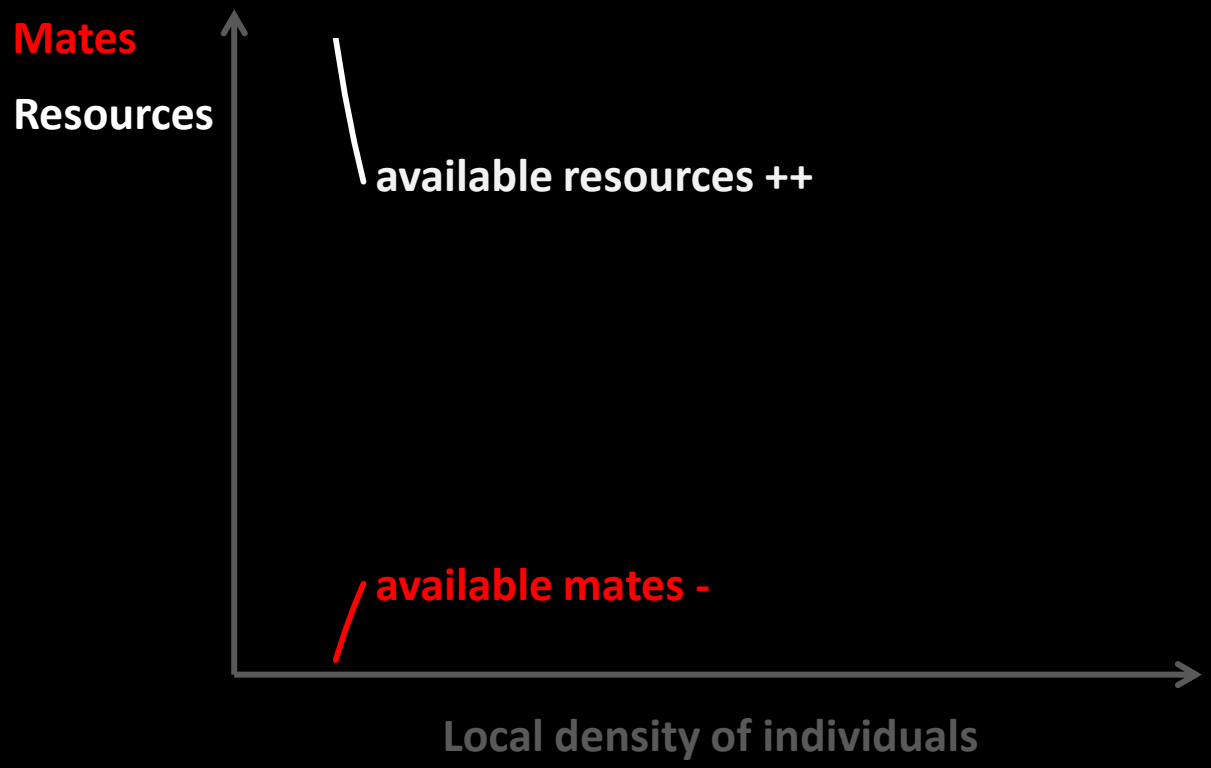
Discussion & Perspectives



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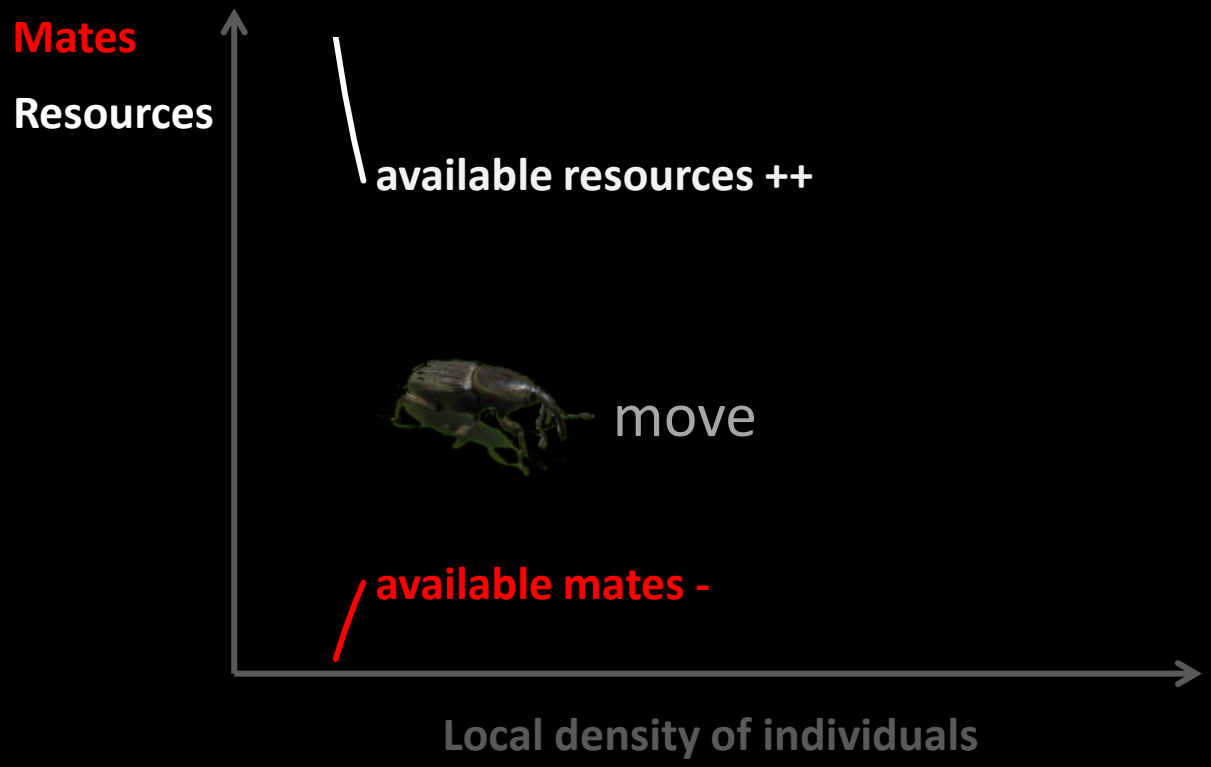
Discussion & Perspectives



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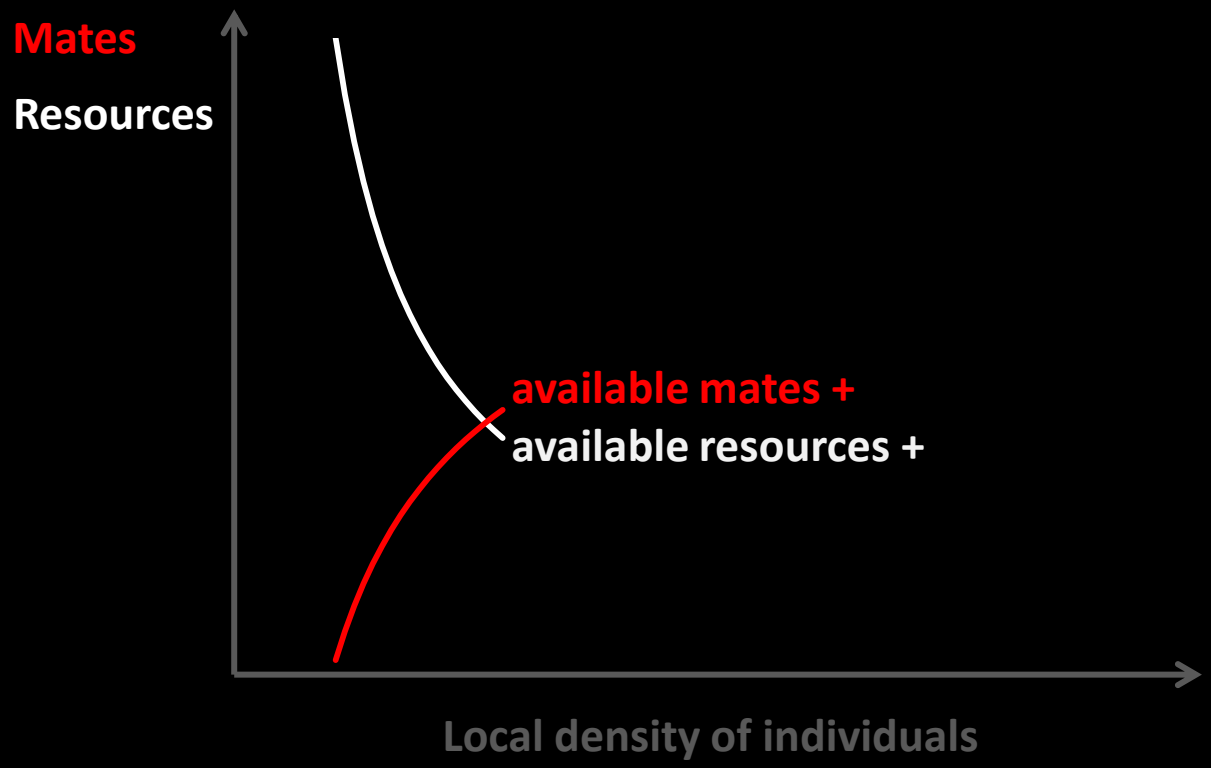
Discussion & Perspectives



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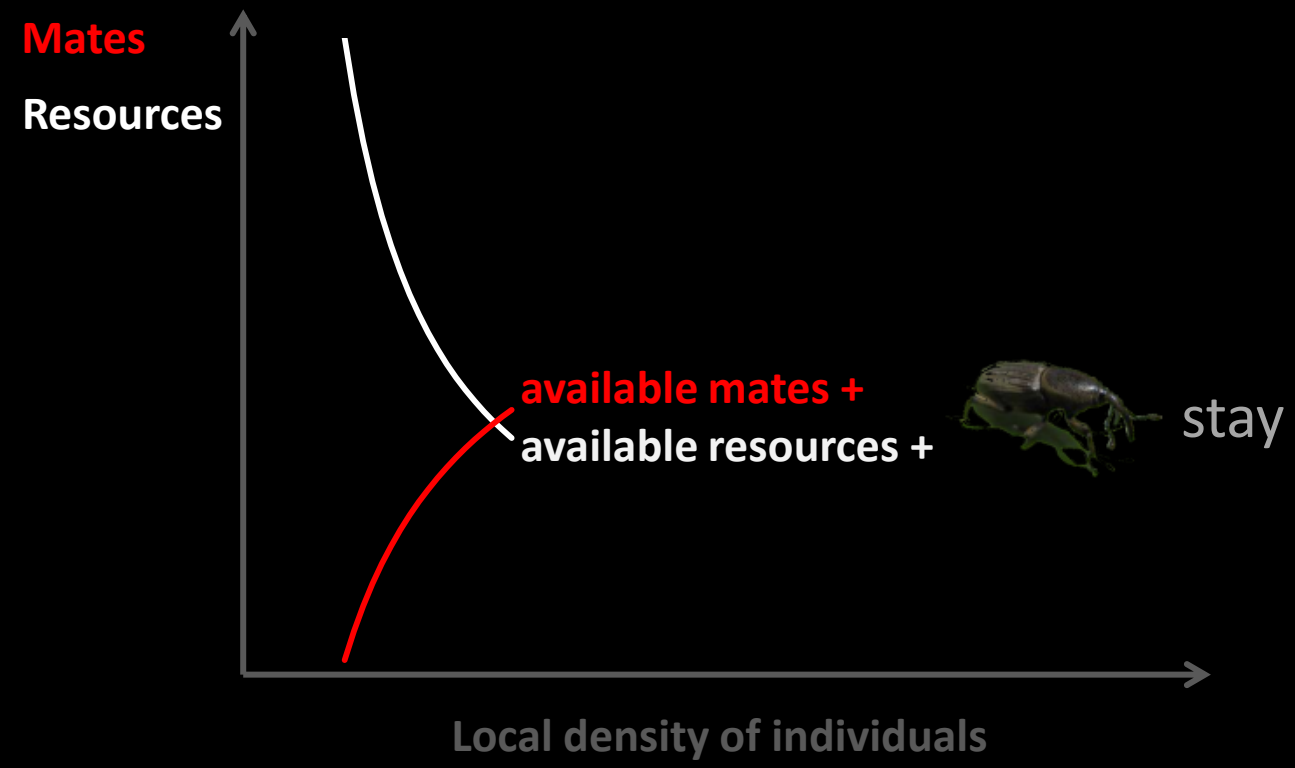
Discussion & Perspectives



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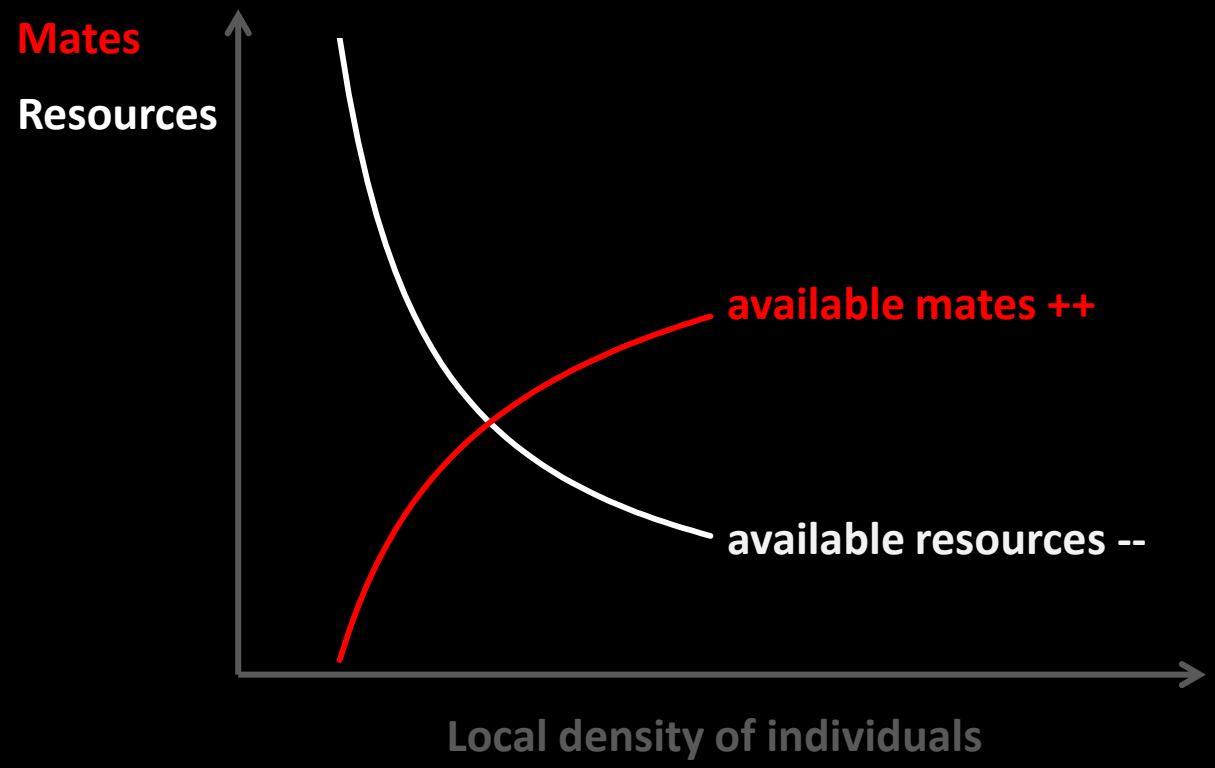
Discussion & Perspectives



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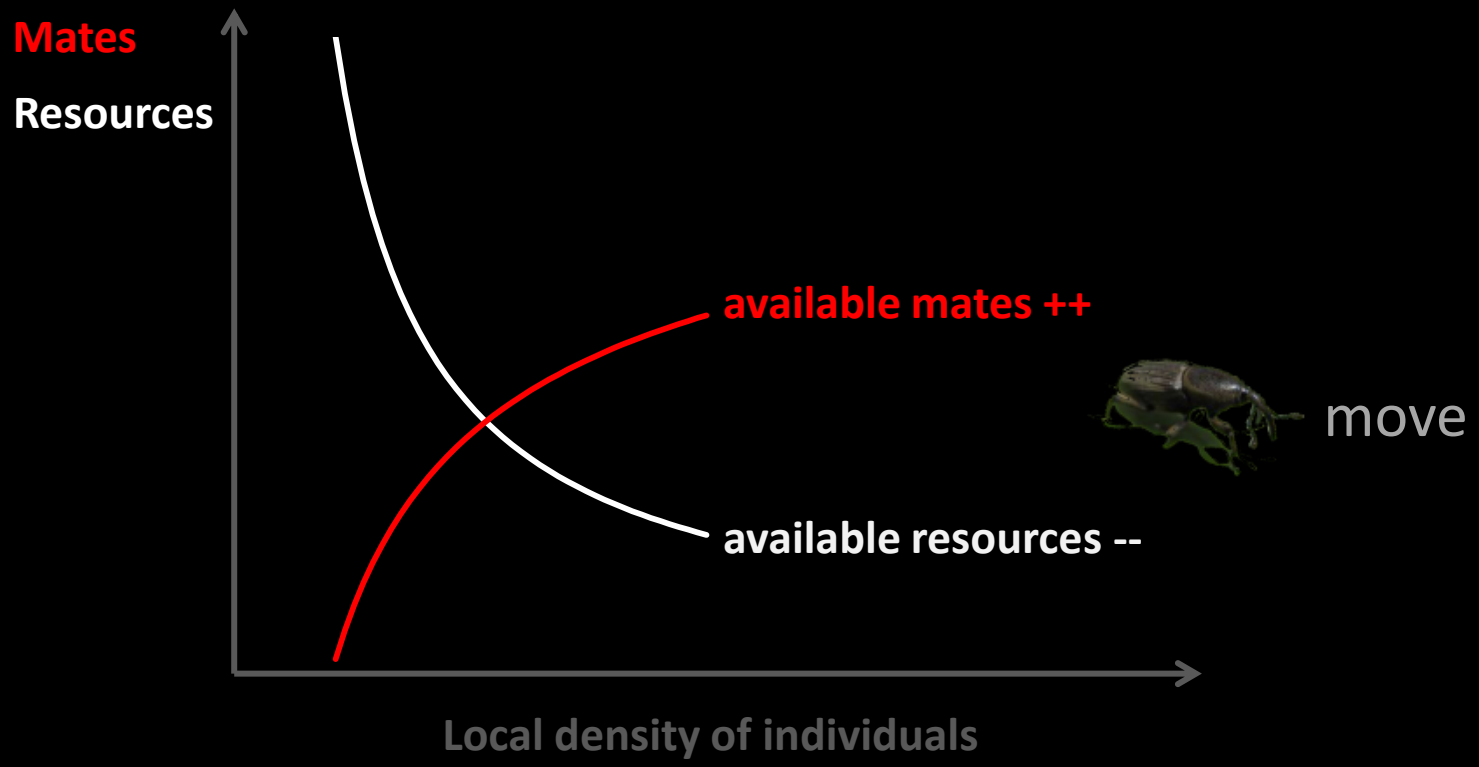
Discussion & Perspectives



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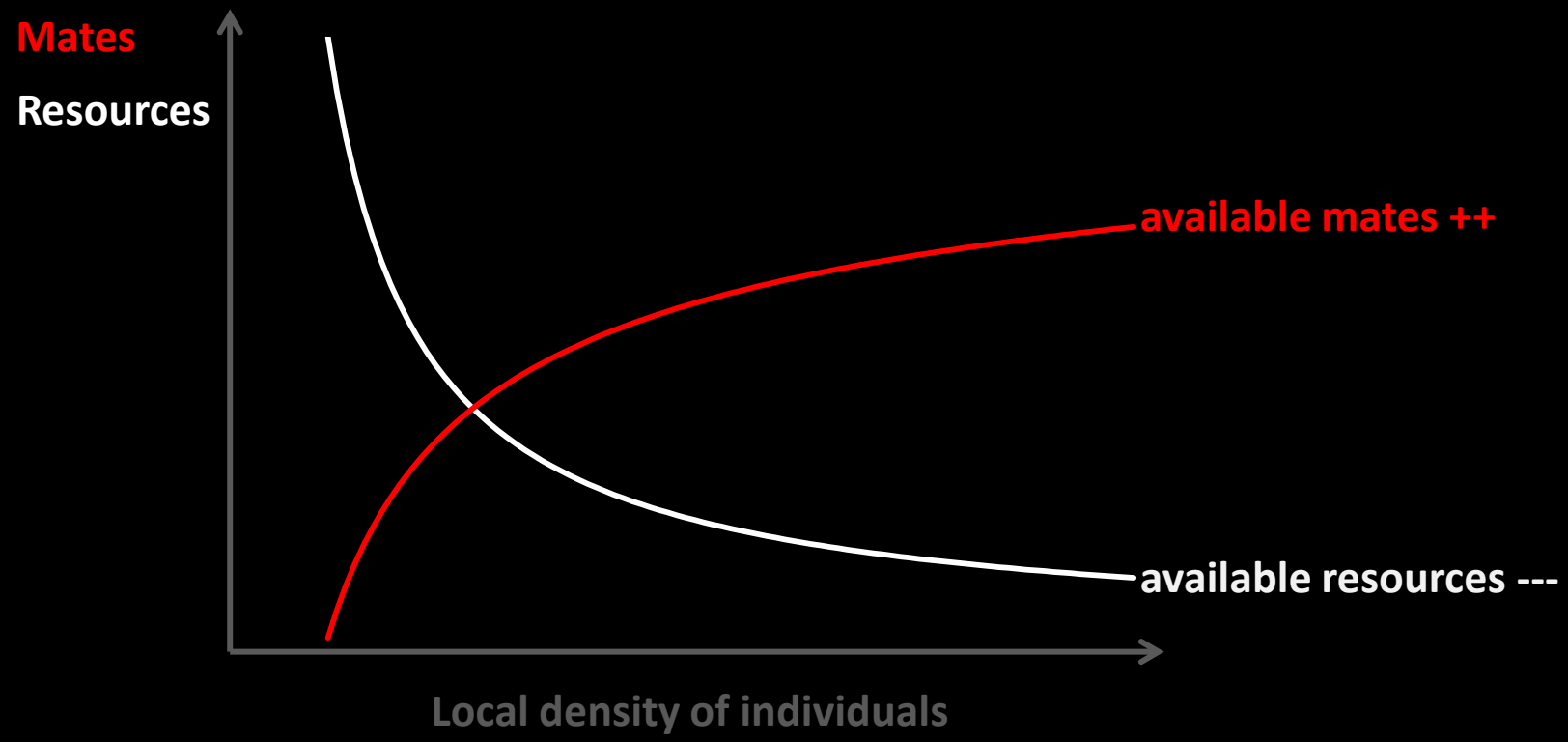
Discussion & Perspectives



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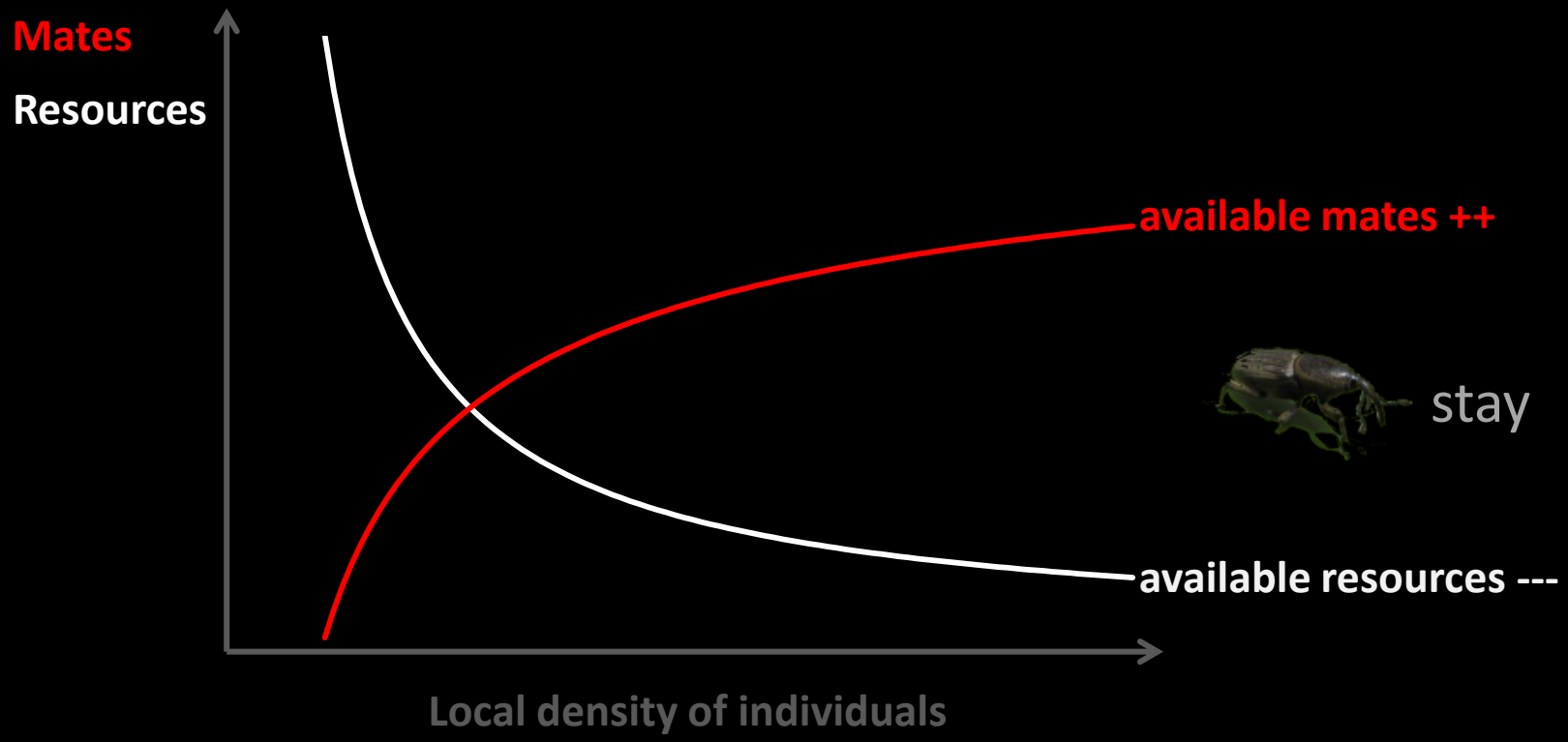
Discussion & Perspectives



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Discussion & Perspectives

How to explain the behavior of* C. sordidus *in response to variation in local density of patch?

Hypothesis : two effects of the local density

How to explain the difference in response to variation in local density of patch between males and females?

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Discussion & Perspectives

How to explain the behavior of* C. sordidus *in response to variation in local density of patch?

Hypothesis : two effects of the local density

How to explain the difference in response to variation in local density of patch between males and females?

Hypothesis : egg laying

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Discussion & Perspectives

More replicates are needed !

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Discussion & Perspectives

More replicates are needed !

Effect of the sex ratio

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Discussion & Perspectives

More replicates are needed !

Effect of the sex ratio

Effect of the size of individuals

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Discussion & Perspectives

More replicates are needed !

Effect of the sex ratio

Effect of the size of individuals

Effect of the mating status

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Discussion & Perspectives

More replicates are needed !

Effect of the sex ratio

Effect of the size of individuals

Effect of the mating status

Modelisation of the patch choice

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Discussion & Perspectives

More replicates are needed !

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Effect of the mating status

Modelisation of the patch choice

Modelisation of epidemiological front

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